



Environmental Security Technology Certification Program (ESTCP) Validation Tasks

Environmental Cost Analysis Methodology (ECAM) Handbook

March 29, 1999

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

Contract No. DAAA21-93-C-0046
Task No. N.098
CDRL No. A013

NDCEE

*National Defense Center
for Environmental Excellence*

*Prepared by
National Defense Center for Environmental Excellence (NDCEE)*

Operated by Concurrent Technologies Corporation

20020508 130

Environmental Security Technology Certification Program (ESTCP) Validation Tasks

Environmental Cost Analysis Methodology (ECAM) Handbook

March 29, 1999

Distribution Statement "A" applies.
Approved for public release. Distribution is unlimited.

Funding to prepare this document was provided by the Office of the Deputy Under
Secretary of Defense for Environmental Security under the Environmental
Security Technology Certification Program

Contract No. DAAA21-93-C-0046
Task No. N.098
CDRL No. A013

Submitted by:

Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904



Environmental Security Technology
Certification Program

Department of Defense
Deputy Undersecretary of
Defense for Environmental
Security (DUSD-ES)

March 29, 1999

Environmental Cost Analysis Methodology **ECAM** Handbook

Contract No. DAAA21-93-C-0046
Task No. N.098

NDCEE

NDCEE National Defense Center for
Environmental Excellence

Operated by:

CTC  *Concurrent Technologies Corporation*

Concurrent Technologies Corporation
1450 Scalp Avenue
Johnstown, PA 15904

**Coopers
& Lybrand**

Coopers & Lybrand L.L.P.

a professional services firm

Coopers & Lybrand L.L.P.
12902 Federal Systems Park Drive
Fairfax, VA 22033

Comments and/or questions regarding this handbook should be directed to
Mr. John R. Thoms, ESTCP Cost Methodology Task Leader
Concurrent Technologies Corporation
Johnstown, PA 15904
Phone (814) 269-6805 or Fax (814) 269-2798
E-mail: thoms@ctc.com

TABLE OF CONTENTS

	Page
FOREWORD	1
INTRODUCTION	3
1.0 ECAM LEVEL I: IDENTIFICATION OF DIRECT COSTS	8
1.1 Process Identification.....	9
1.2 Flow Diagram Development.....	10
1.3 Process Resources Quantification.....	11
1.4 Direct Cost Identification.....	14
1.5 Capital Cost	15
2.0 ECAM LEVEL II: IDENTIFICATION AND ASSIGNMENT OF ENVIRONMENTAL ACTIVITY COSTS	15
2.1 Identification of Environmental Activities	17
2.2 Identification of Resources Consumed by Environmental Activities.....	18
2.3 Identification of Environmental Activity costs.....	19
2.4 Assignment of Environmental Activities Costs to Process.....	22
3.0 ECAM LEVEL III: IDENTIFICATION AND ASSIGNMENT OF OTHER COSTS	25
3.1 Identification and Assignment of Support and Overhead Costs	25
3.2 Productivity Costs and Benefits.....	26
4.0 FINANCIAL ANALYSIS.....	28
4.1 Fundamental ECAM Assumptions	28
4.2 Life Cycle Cost Analysis	29
4.3 Financial Performance Measures	30
Payback Period.....	31
Internal Rate of Return.....	33
Summary of Investment Performance Measures	33
4.4 Final Report Preparation	35
5.0 QUALITATIVE ISSUES	35
5.1 Product Quality	36
5.2 Public Image	37
5.3 Potential Liability	38
Unit Cost Estimates	38
Probabilistic Cost Estimates	38
5.4 Employee Health and Safety Considerations.....	39
GLOSSARY	40
BIBLIOGRAPHY	44

APPENDICIES

- A ECAM Summary
- B-1. Data Collection Forms
- B-2. Blank Process Flow Diagram
- B-3. Blank Input/Output Diagram
- B-4. Environmental Activities Checklist
- B-5. Checklist of Qualitative Environmental Factors
- C. P2/FINANCE Overview and Application
- D. Monte Carlo Simulation
- E. Guidelines
- F. Assumptions

LIST OF TABLES

	Page
1. General Information Categories and Examples.....	8
2. Sample Resources Consumption	13
3. Direct Process Costs (Current Process).....	15
4. Direct Process Costs (Proposed Process)	15
5. Sample Environmental Resources.....	18
6. Sample Resources and Drivers for Environmental Activities.....	19
7. Summary of Resource Drivers and Unit Costs for EHS Training.....	21
8. Environmental Activity, Drivers, Quantities, and Costs for Process	22
9. Resources, Drivers, and Costs for Environmental Activities (Current Process).....	23
10. Environmental Activities (Proposed Process).....	24
11. Potential Annual Savings Generated by Reductions in Inventory Holding Costs	27
12. Summary of Investment Criteria	34
13. Sample Summary of Financial Indicators Generated in The ECAM Sensitivity Analysis	34

LIST OF FIGURES

	Page
1. ECAM Concept	5
2. ECAM Approach.....	7
3. Sample Overall Process Flow.....	10
4. Sample Input/Output Flow	11

FOREWORD

The U.S. Department of Defense (DOD) is demonstrating and validating promising, innovative technologies that target urgent environmental needs. In addition to being environmentally preferred, these technologies should provide a return on investment through cost savings and improved efficiency.

The Office of the Deputy Under Secretary of Defense for Environmental Security (DUSD-ES) tasked Concurrent Technologies Corporation (CTC), through the National Defense Center for Environmental Excellence (NDCEE), in cooperation with Coopers & Lybrand, L.L.P., to design a method for making consistent and reliable environmental investment and project selection decisions. In response, the Environmental Cost Analysis Methodology (ECAM) was developed to provide a consistent means of quantifying and evaluating environmental costs and benefits.

The ECAM is a tool for evaluating investments in environmental technologies that address compliance and pollution prevention issues. The ECAM was validated at Lake City Army Ammunition Plant (LCAAP), Independence, Missouri, where an ammunition manufacturing process is being modified to reduce the use of hazardous materials. The ECAM has been applied at five DOD locations in which environmentally preferred technologies have already been fielded or are being evaluated for future use. Each of these technologies is designed to eliminate or reduce potentially adverse environmental impacts, while simultaneously cutting costs and maintaining or improving product quality.

The ECAM is a capital investment decision tool used by process engineers, with input from facility accounting personnel, to perform economic analyses—especially when environmental costs are a factor.

The ECAM was developed to provide a consistent means of quantifying and evaluating environmental costs and benefits.



The ECAM was designed to evaluate environmental technologies that address compliance and pollution prevention issues.



The ECAM was *not* designed as a life cycle costing tool to evaluate new systems over the entire weapon system life cycle, rather it was designed to evaluate individual process technologies fielded in the operations and support phase.

The ECAM focuses primarily on quantifying and evaluating costs associated with the selected environmental technology. Qualitative issues are also addressed by the ECAM, but to a lesser extent.

The scope of the ECAM is presently limited to facility-specific cost information and does not quantify future environmental liability costs or intangibles such as opportunity costs, quality of life, and resource depletion. It is anticipated that revised versions of the tool will be released following further validation.

The ECAM is a capital investment tool.

INTRODUCTION

The Environmental Security Technology Certification Program (ESTCP) serves as a demonstration and validation program for innovative technologies that target urgent environmental needs, as identified by the U.S. Department of Defense (DOD). In addition to being environmentally preferred, these technologies provide a return on investment through cost savings and improved efficiency. To validate those savings, the ESTCP needs a consistent method of identifying and quantifying capital and operating costs, specifically environmental costs.

The Environmental Cost Analysis Methodology (ECAM) Handbook was developed by the National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (CTC), and Coopers & Lybrand, L.L.P. (C&L). The Handbook is to provide users with a consistent and accurate tool for conducting financial analyses, especially where new technologies are being considered. The ECAM integrates activity-based costing (ABC) concepts and techniques for analyzing and evaluating new or modified technologies.

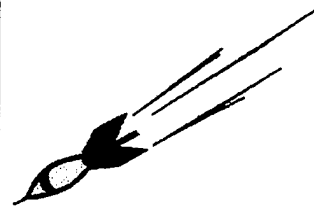
Current cost analysis and assignment practices may be incomplete in scope because significant costs are overlooked and not assigned with the degree of accuracy required to make informed management decisions. In particular, environmental costs can be inappropriately assigned as a result of these shortcomings. The ECAM overcomes or minimizes the impact of such shortcomings for several reasons:

- A consistent approach is used to identify relevant costs and assign them with a higher degree of accuracy;
- Environmental costs and benefits are identified, quantified, and assigned to the process responsible for generating them more appropriately;
- Standard financial indicators (Net Present Value, Payback Period, and Internal Rate of Return) are provided to decision makers, regardless of the technologies and processes analyzed;

The ESTCP is a demonstration and validation program for innovative and environmentally preferred technologies.

The ECAM responds to the need for a practical tool to identify and assign environmental costs.

The ECAM overcomes many shortcomings of traditional cost analysis practices.



- Financial indicators are calculated using a standard, easy-to-use software tool that clearly states assumptions such as period of study, discount rate, and capital costs.¹

The ECAM is a capital investment decision tool to be used by process engineers when performing economic analyses—specifically where environmental costs are a factor. This Handbook provides practical guidance for applying the ECAM and significantly improving the identification and assignment of conventional and environmental costs. The definitions used throughout this handbook are consistent with the terminology used in the EPA's primer, *An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms*.²

The ECAM recognizes time and cost constraints with regard to data collection requirements and adopts an implementation approach consisting of three levels. Figure 1 shows the benefits of the ECAM implementation, along with a qualitative indication of its advantages over traditional methods. Each level of the ECAM implementation incrementally improves the accuracy of the cost identification process. Each level of implementation is explained in the following sections.

The ECAM was designed for Process Engineers.

This handbook shows users how to conduct an economic analysis using ECAM.

The ECAM can be implemented in three levels, each one providing incremental improvement of cost identification and the accuracy of cost assignment.

¹ FINANCE Rel 3.0, Tellus Institute, Boston

² EPA 742-R-95-001, *An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms*, June 1995

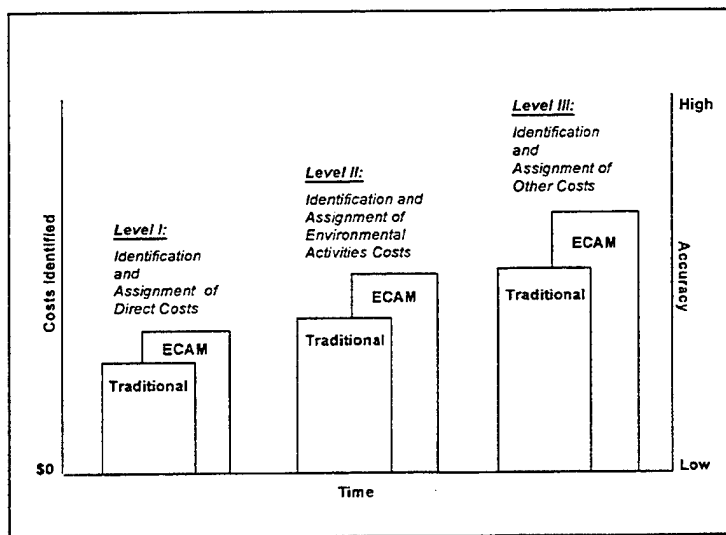


Figure 1. Benefits of ECAM

Level I (Section 1) explains how to accurately identify *direct costs*—costs associated with the process operations. These include resource costs, such as labor, materials, and utilities, that are directly consumed by the process being analyzed. These costs are sometimes overlooked in business decision making when traditional methods are used. Level I identifies *environmental costs* that also may be considered direct costs, such as consumption costs.

Level I identifies and assigns direct costs, including some environmental costs.

Level II (Section 2) identifies and assigns *indirect costs* and focuses on environmental costs which are often overlooked by traditional cost analysis methods. This Handbook provides practical guidance in identifying these potentially overlooked indirect or hidden environmental costs. These costs include hazardous waste management costs, environmental training, permitting, and other items generally consider indirect or overhead costs. These costs are assigned to the process with a higher degree of accuracy by using activity-based costing (ABC) concepts and techniques.

Level II identifies and assigns costs incurred by carrying out facility environmental activities supporting the process.

Level III (Section 3) provides guidance on identifying, quantifying, and assigning other non-environmental support and overhead costs. Technology improvements can lower these costs by improving the facility's efficiency and productivity. Level III application provides a broader understanding of the viability of a proposed project. An

example process improvement may be the reduction in cycle time or increased production capacity associated with implementing a new technology.

The ECAM user determines the level of analysis required to effectively evaluate the process. Selecting for study the next higher level increases the confidence in the collected data, and usually, additional costs and benefits are identified. However, it may not be necessary to proceed to Level III to obtain the information needed to make a final decision.

As a general guideline, Levels I and II should always be performed, while Level III should be implemented when there is a potential to identify significant costs and process improvement benefits that may affect a final recommendation or decision. Users would generally proceed to Level III where the Level I and Level II financial performance measures were inconclusive or marginally below the performance acceptance level desired.

Section 4 describes the financial analysis process and how to interpret the information collected during the ECAM implementation.

Figure 2 illustrates the three-level approach to use when applying the ECAM. This approach is the end result of refining what was initially a four-step exercise. The four steps consisted of 1) data collection, 2) identification of environmental activities, costs, and drivers, 3) quantification of costs, and 4) economic analysis of the data. These steps were integrated into three levels to reflect different levels of effort that may be expended in implementing the ECAM. As users apply the ECAM at each increasing level, it is possible to obtain results that are more accurate. Level I requires only that direct costs be identified and quantified. Level II is somewhat more rigorous requiring users to identify and quantify indirect environmental costs. Level III extends the ECAM application to include other indirect costs that might be impacted by the proposed process change. Examples of Level III costs and benefits include reducing inventory carrying costs, or decreasing process cycle times. It is recommended that both Level I and Level II be included as a minimum in all uses of the ECAM. Regardless of the level at which the ECAM is applied, costs are quantified and results of the economic analysis are calculated.

Level III identifies and assigns other non-environmental overhead and support costs and quantifies benefits.

Users determine the level of analysis needed.

The ECAM provides guidance on performing financial analysis.

ECAM APPROACH

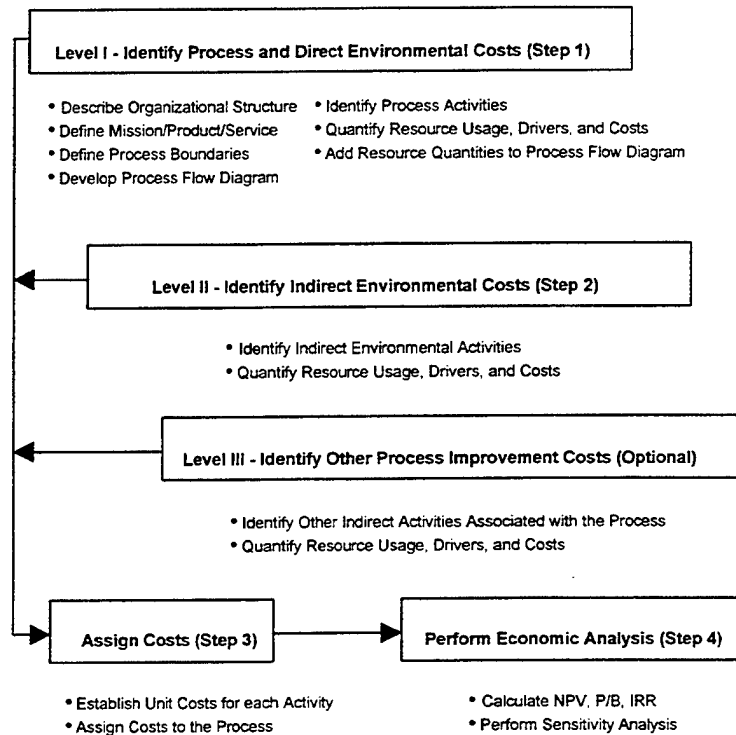
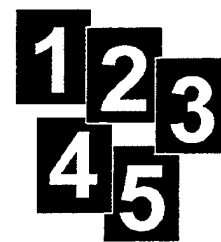


Figure 2. ECAM Approach

Section 5 shows users how to perform qualitative analysis on less tangible environmental issues.

Users must become familiar with the basic concepts and terminology used throughout this handbook to successfully implement the ECAM. To help meet this need, fundamental terms and concepts are explained in the Glossary.

The ECAM Handbook discusses ways to incorporate qualitative issues in the economic analysis.



1.0 ECAM LEVEL I: IDENTIFICATION OF DIRECT COSTS

Level I describes how to identify costs associated with a process under evaluation. This includes identifying costs for both the current and proposed technology.

As with any cost analysis, it is important to collect accurate data. In doing so, a benefit of the ECAM is that it uses information that is readily available. Organizations are not expected to collect non-standard data or to develop a new accounting system to use the ECAM successfully. Table 1. provides examples of readily available data sources to consider when using the ECAM.

Table 1. General Information Categories and Examples

CATEGORY	EXAMPLES
Process Information	<ul style="list-style-type: none">Existing flow diagramsJob descriptions
Accounting Information	<ul style="list-style-type: none">Current accounting systemCapital and operating budgetGeneral financial informationCapital equipment information
Environmental Information	<ul style="list-style-type: none">A checklist of environmental activitiesApplicable environmental, health, and safety activities

The ECAM implementation begins by clearly defining the process.

The ECAM relies on accurate data collection.

The following items associated with the process under evaluation should be collected to successfully complete the ECAM Level I:

- Definition of the process and process boundaries;
- Development of process flow diagrams;
- Quantification of resources used in performing the process;
- Identification of unit costs associated with the quantities of the resources used in the process.

This procedure is to be applied to both the existing process and the proposed alternative process.

1.1 Process Identification

In general, a process is defined as a functional sequence of events or actions (*steps*) that generate a desired output. The first task involves the selection of the *process* to be analyzed. Examples include industrial manufacturing processes that cause environmental impacts, such as plating of aircraft components and chemical stripping of metal coatings.

The scope of the ECAM implementation is defined by the system boundaries or the specific steps within the overall process which are to be evaluated. Setting the process boundaries too wide will result in unnecessarily complicating the analysis; too narrow, and important costs may be overlooked.

By outlining the process boundaries the flow of *resources*, such as labor, materials, and utilities, can be identified. Resources represent the assets of the organization that are consumed during various steps in the process. Within the process boundaries, these resources are used to produce the process outcome.

It is helpful to prepare a brief written description of both the process to be substituted and the process that uses the new technology, highlighting the important differences between each.

The ECAM Level I begins by defining the process and its boundaries and ends with accurately identifying direct costs.



A process is a series of steps that generate a desired output.

Process boundaries define the scope of the analysis.

The process uses resources to produce an output.

A brief process description should be prepared.

1.2 Flow Diagram Development

Flow diagrams are prepared to clearly identify the steps within the process. Flow diagrams are developed using standard engineering techniques for process analysis and mapping³. Overall flow diagrams depict each step in the process as a separate event working toward a final product or outcome. Using available information and direct observation, this sequence of steps can be mapped as a process flow diagram such as the one shown in Figure 3.

Overall flow diagrams identify the steps within a process and establish an accurate baseline for further process investigation and analysis. Process steps requiring additional environmental evaluation, such as those generating unwanted by-products, become more evident as a result. Process steps requiring an environmental activity (such as permitting or specific environmental training) to support them are also highlighted.

Detailed flow diagrams are developed using the process mapping techniques described in the following section. Examples of process flow diagrams are also provided in Appendix B.

A flow diagram is a visual representation of the overall process, using information gathered on-site.

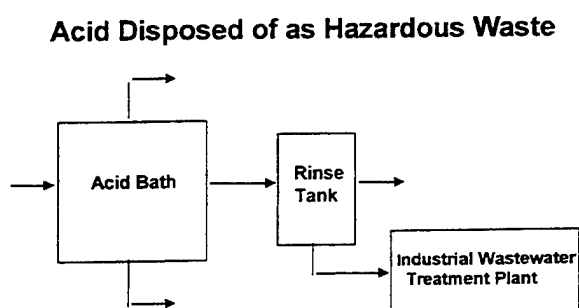


Figure 3. Sample Overall Process Flow

³ *Benchmarking: The Primer, Benchmarking for Continuous Environmental Improvements*, Washington, DC: Global Environmental Management Initiative, 1991.

1.3 Process Resources Quantification

A completed process flow diagram can be used to track the resources used in each process step. This approach uses a technique similar to the material and energy balance diagrams used in engineering analysis to develop a labor, material, and energy flow diagram. The ECAM tracks labor and other resources that are used, or consumed, in each process step. The resources represent an input to the process and are transformed or consumed according to the sequence of steps until the final output is generated.

The ECAM identifies the quantities of the resources used to each step in the process. Material, utilities, and labor inputs and outputs are tracked and associated with each process step being analyzed.

For example, process steps using hazardous materials and producing hazardous waste should be identified. The associated quantities of the inputs and outputs may include hazardous chemicals and waste by-products such as contaminated rinse water. The ECAM's systematic approach increases the precision of the analysis and the likelihood that often overlooked environmental costs will be considered.

The process flow diagram is used to track resources consumed in each step and to generate a balanced resource flow diagram.

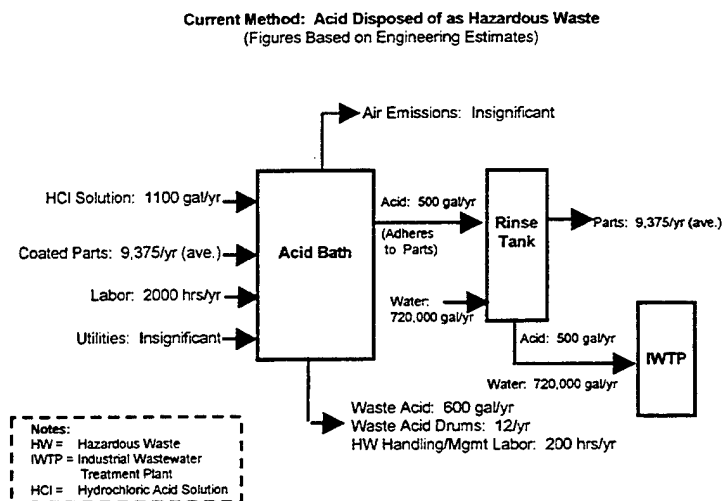


Figure 4. Sample Input/Output Flow

The final outcome of this task is an input/output (I/O) diagram such as the one shown in Figure 4. The diagram contains information about the resources consumed by the process as well as its products and by-products (i.e., waste streams).

The same procedures are to be applied to the proposed technology, and a corresponding I/O diagram must be developed

Each resource is consumed at a given rate (*driver*). The driver is the rate at which a resource is consumed by the *activity* within the step in the process. Therefore the resource driver identifies the causal relationship of the resource consumption during each activity. For example, the resource "labor" is consumed as a function of the "number of parts processed" or "number of waste drums shipped". Table 2 provides an example based on the resource flow diagram shown in Figure 4.



The resource driver determines the relationship between resource consumption and an activity.

Table 2. Sample Resources Consumption Table

RESOURCE	ESTIMATED ANNUAL QUANTITY	
	CURRENT METHOD	PROPOSED METHOD
Deionized water added to Diffusion Dialysis	0	900 gal
* Hazardous Waste drums (55-gallon)	12	0
* Hazardous Waste generated/managed	600 gal	0
HCl sent to rinse tank/Industrial Wastewater Treatment Plant	500 gal	500 gal
Hydrochloric Acid added to acid bath	1100 gal	980 gal
Labor for acid dip (direct)	2000 hrs	1800 hrs
Labor to manage/handle Hazardous Waste	200 hrs	0
* Labor to operate Diffusion Dialysis system	0	200 hrs
* Utilities	Insignificant	Insignificant
* Wastewater sent to Industrial Wastewater Treatment Plant	720,000 gal	721,380 gal

* Also considered a resource consumed by environmental activity.

The collection of reliable quantitative information is an important task that impacts the accuracy of the entire analysis. Resource quantities consumed by the process can be obtained through direct process observation, by reviewing inventory and purchase records, and by interviewing managers and staff personnel. Utility data can be collected by reviewing utility bills, examining equipment plates, and taking measurements where appropriate. Utilities include electric energy, water, gas, and other infrastructure support. The process information checklists provided in Appendix B to the Handbook aid in the collection process.

The outcome of this task is the total quantity of the resources consumed by the process steps, expressed on an annual basis.

1.4 Direct Cost Identification

Calculating the total direct costs of the process is the final task in completing The ECAM Level I. Resource quantities have been identified and totaled at this point.

To define the costs associated with the consumption of resources, users must merge quantity information provided by process managers with cost information provided by the facility accounting staff. The information extracted by the facility accounting systems, however, may not be readily available or conveniently formatted. At this stage, an accurate cost estimate based on an engineering calculation may represent a viable alternative.

Existing cost-benefit analyses studies, department budgets, invoices, receipts and various other financial data are good information sources. It is important; however, to validate these types of information with the information contained in the facilities cost accounting system. If process managers cannot link the cost information to the facility's accounting system, actual savings and benefits cannot be demonstrated.

Once the cost information has been gathered, users must determine the unit cost of each resource consumed in the process. The unit cost is simply the total cost divided by the total quantity of the resource consumed.

For example, if the organization spent \$484,000 on environmental training and trained 300 employees during the year; the unit cost would be \$1,266 per employee.

The annual cost associated with each resource consumed during an activity is then obtained by multiplying the unit cost by the annual driver (quantity consumed) for that activity. For the previous example, if two individuals are assigned to the process the cost of environmental training associated with the process would be \$2,522 per employee ($\$1,266 \times 2 = \$2,522$). This task must be completed for both the current and proposed methods when comparing an existing process to a new one, as shown in Tables 3 and 4.

Table 3. Direct Process Costs (Current Process)

RESOURCE	ANNUAL QUANTITIES USED AND COST FACTORS		ANNUAL COST
Hazardous Waste drums (55-gallon)	12 drums	\$65/drum	\$780
Hydrochloric Acid added to bath	1100 gal	\$3.14/gal	\$3,450
Industrial Wastewater Treatment Plant (Hydrochloric Acid + wastewater)	720,500 gal	\$18.94/kgal	\$13,646
Labor for acid dip	2,000 hrs	\$60/hr	\$120,000
Direct process labor to manage/handle HW	200 hrs	\$60/hr	\$12,000
Utilities (lighting, heating, air conditioning)	1,000 ft ²	\$0.50/ft ²	\$500
Total	—	—	\$150,376

The ECAM Level I is completed when all the direct costs have been identified, so that the sum of the direct process cost can be totaled.

Table 4. Direct Process Costs (Proposed Process)

RESOURCE	ANNUAL QUANTITIES USED AND COST FACTORS		ANNUAL COST
Hazardous Waste drums (55-gallon)	0 drums	\$65/drum	\$0
Deionized water added to Diffusion Dialysis	900 gal	\$0.03/gal	\$27
Hydrochloric Acid added to bath	980 gal	\$3.14/gal	\$3,074
IWTP (HCl + wastewater)	721,880 gal/yr	\$18.94/kgal	\$13,672
Labor for acid dip + Diffusion Dialysis	2,000 hrs	\$60/hr	\$120,000
Direct process labor to manage/handle Hazardous Waste	0 hrs	\$60/hr	\$0
Utilities (lighting, heating, air conditioning)	1,000 ft ²	\$0.50/ft ²	\$500
Utilities (electricity for Diffusion Dialysis)	0.22 kWh/hr, 24 hrs/day, 350 days/yr	\$0.035/kWh	\$65
Total	—		\$137,338

Note that direct costs include both “conventional” and “environmental” costs. The ECAM’s successful application does not depend on the precise classification of direct costs as either conventional or environmental. The ECAM’s main goal is to provide decision makers with total relevant cost information on the process under evaluation.

1.5 Capital Cost

Complete identification of conventional direct costs should include *capital equipment* costs of the proposed new technology. Cost information of major equipment involved in the process under evaluation should include the date of acquisition, purchase price, installation and start-up costs, and its useful life.

Other *initial investment* costs, such as design, site preparation, installation, and start-up costs should also be considered.

Cost associated with the old process are generally considered a sunk cost, having no economic value. There may be a positive *salvage* value to the existing technology, however. The capital cost of the new technology can be reduced by the estimated revenue earned from the sale of the old equipment

2.0 ECAM LEVEL II: IDENTIFICATION AND ASSIGNMENT OF ENVIRONMENTAL ACTIVITY COSTS

The ECAM Level II seeks to establish the costs of additional *environmental activities* supporting the process under consideration. Such activities are usually performed for the entire facility. A portion of these environmental activities supports the process under evaluation, and its cost is to be assigned to the process.

To determine facility indirect environmental costs, one must first identify the environmental activities, the resources consumed, and the causal relationships (unit cost) between the environmental activities and the resources used to perform them. Once this is completed, environmental activity costs can then be assigned to the process.

The ECAM Level II involves:

- Identifying the environmental activities supporting the process;
- Identifying resources consumed by environmental activities;
- Identifying the unit cost for the environmental activities;
- Assigning environmental costs to the process.

The ECAM's successful application does not depend on the precise classification of direct costs as either conventional or environmental.

Capital equipment costs are direct costs.

2.1 Identification of Environmental Activities

To determine environmental activity costs, one must first identify all of the environmental activities performed within a facility. These can then be evaluated to determine which activities are associated with the process under consideration. These activities can be compiled using an environmental activities checklist, as shown in Appendix B.

Listed below are examples of environmental activities for the sample process depicted in section 1.0.

- Documentation maintenance (e.g., MSDSs, emergency plans)
- Compliance audits (internal, external)
- EHS training (instructor/contract labor)
- EHS training (loss of productive labor)
- Environmental management plan maintenance (e.g., HW Management Plan, Pollution Prevention Plan)
- Reporting requirements (e.g., federal, state, EPCRA/TRI)
- Test/Analyze waste streams
- Sample waste streams
- Waste disposal (off-site)
- Medical exams (medical/contract labor)
- Medical exams (loss of productive labor)
- Transport wastes on site
- Permitting requirements (e.g., CAA, state, local)

An environmental activities checklist helps identify the appropriate environmental activities.

Once environmental activities are determined, the resources they consume can be identified.

-
- Hazardous waste manifest preparation
- Hazardous waste container labeling
- Hazardous waste storage/ accumulation area maintenance
- EHS training (includes loss of productive labor hours)
- Internal Audits

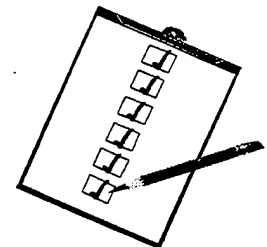
Resources consumed by environmental activities can be identified through direct interviews and review of facility records.

2.2 Identification of Resources Consumed by Environmental Activities

Resources consumed by the process, such as labor, materials, and contractor services, must be identified for each environmental activity. Resources represent the assets of the organization that are consumed in the performance of various activities. Table 5. provides some examples of resource categories and environmental resources.

Table 5. Sample Environmental Resources

ENVIRONMENTAL ACTIVITY	RESOURCES
1. Compliance audits (internal, external)	Labor
2. Documentation maintenance (MSDSs, emergency plans)	Labor
3. EHS training (instructor/contract labor)	Contractor Labor & Material
4. EHS training (loss of productive labor)	Labor
5. Environmental management plan maintenance (HW Management Plan, Pollution Prevention Plan)	Labor
6. Reporting requirements (federal, state, EPCRA/ TRI)	Labor
7. Test/Analyze waste streams	Contractor Labor & Material
8. Sample waste streams	Labor
9. Waste disposal (off-site)	Contractor Services
10. Medical exams (medical/contract labor)	Contractor Labor
11. Medical exams (loss of productive labor)	Labor
12. Transport wastes on site (indirect, non-process labor)	Labor



2.3 Identification of Environmental Activity costs

In the previous task, environmental activities were linked to the resources they consume. The next task is to define *cause-and-effect relationships* between those activities and resources. According to activity-based costing principles, variables used to define this relationship are referred to as *environmental activity drivers*, which allow the appropriate cost to be assigned. The drivers selected must be measurable in terms of unit and cost, and must be those that best describe the relationship between the environmental activity and the resources consumed. Table 6. illustrates this further by listing the resources and drivers associated with several environmental activities.

Environmental activity drivers define the relationship between environmental activities and the resources they consume.



Table 6. Sample Resources and Drivers for Environmental Activities

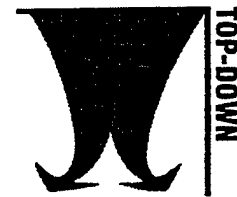
ENVIRONMENTAL ACTIVITY	RESOURCES	ACTIVITY DRIVER
1. Compliance audits (internal, external)	Labor	Number of waste streams
2. Documentation maintenance (MSDSs, emergency plans)	Labor	Number of waste streams
3. EHS training (instructor/contract labor)	Contractor Labor and Material	Number of persons
4. EHS training (loss of productive labor)	Labor	Number of persons
5. Environmental management plan maintenance (HW Management Plan, Pollution Prevention Plan)	Labor	Number of waste streams
6. Reporting requirements (federal, state, EPCRA/ TRI)	Labor	Number of waste streams
7. Test/Analyze waste streams	Contractor Labor & Material	Number of waste streams
8. Sample waste streams	Labor	Number of waste streams
9. Waste disposal (off-site)	Contractor Services	Waste volume
10. Medical exams (medical/contract labor)	Contractor Labor	Number of persons
11. Medical exams (loss of productive labor)	Labor	Number of persons
12. Transport wastes on site (indirect, non-process labor)	Labor	Number of waste drums

Once this list is compiled, environmental activity costs can then be identified. For example, *compliance audits* consume *labor*. Conceptually, the process with the greatest number of waste streams will have allocated the largest compliance audit cost. The quantity of labor consumed is a function of the number of waste streams associated with a process. That is, the environmental activity driver is the number of waste streams. The environmental activity cost is then given by the number of waste streams multiplied by the unit cost of carrying out the activity for one waste stream.

This is a key point in The ECAM application. The information that can be collected cost effectively drives the ECAM implementation. It is not strictly necessary to evaluate the cost of performing environmental activities for an entire facility. The ECAM users can choose between two approaches: the *top-down* approach, which uses data rolled up to the facility level and is available in accounting records, or the *bottom-up* approach, which focuses on the process and uses information generated by engineering estimates and process documentation. The bottom-up approach is usually more practical and cost effective to apply.

In the top-down approach, financial data are extracted from the accounting system in order to identify total cost for each environmental activity for the facility.

The total annual cost for the resource consumed by each activity is divided by the driver quantities to calculate a unit cost for each environmental activity identified. Quantity information about the environmental activity drivers is drawn from interviews with technical, environmental, and accounting personnel. Process managers and environmental staff can provide narrative descriptions of the environmental costs associated with the process, while the accounting staff can help trace these costs to the cost accounting system or other financial records. Appendix B provides a checklist that assists in the collection of facility information.



Existing facility accounting information can be used to extract environmental activity costs.

The top-down approach can be shown using *EHS Training* as an example. For this illustration, EHS Training consumes three resources; direct labor, contract labor, and training supplies.

Next, total facility costs for each of these resources is needed. (This may be available in the cost accounting system or other accounting reports.) If this information is not readily available, it is reasonable to estimate this cost. For this example, total costs for these resources are as follows:

- Direct labor = \$432,000
- Consultant = \$30,000
- Training supplies = \$24,600.

Next, a driver must be identified that helps tie an appropriate portion of the total facility cost to the process under study. The driver chosen here is *number of people trained*.

To continue this example, it is assumed that 300 people are trained. At this point, it is possible to generate a *unit cost* for each resource by dividing the total facility cost for each resource by the driver quantity. Unit costs are summarized in Table 7.

Table 7. Summary of Resource Drivers and Unit Costs for EHS Training

RESOURCE	TOTAL FACILITY COST	DRIVER	DRIVER QUANTITY	UNIT COST
Labor	\$432,000	people	300	\$1,440
Consultant	\$30,000	people	300	\$100
Training supplies	\$ 24,600	people	300	\$82

To establish the unit cost, divide the total cost for environmental training by the total number of persons trained

÷

X

Now, by identifying the driver quantity associated with the specific process, it is possible to estimate an appropriate portion of total facility costs to the process under study.

The bottom-up approach is also described in the following section. Note that cost data used by the bottom-up approach is usually not derived from accounting ledgers or operating statements. Rather, engineering estimates and other engineering or cost studies are a more likely source. This method, therefore, may be less accurate. Ideally, both the bottom-up and top-down approaches will be used together to increase confidence in the data and results.

2.4 Assignment of Environmental Activities Costs to Process

In this section, a driver quantity is identified for each resource consumed by the environmental activity associated with the process under study. Continuing with the example from section 2.3, the number of people associated with each activity for the process are identified in Table 8. For this example, two operators are assumed to be needed to operate the equipment. This table also shows annual costs calculated for each activity.

Table 8. Environmental Activity, Drivers, Quantities, and Costs for Process

ENVIRONMENTAL ACTIVITY: EHS TRAINING				
RESOURCE	DRIVER	PROCESS QUANTITY	UNIT COST	ACTIVITY COST
In-house labor	number of people trained	2	\$1,440	\$2,880
Contract labor	number of people trained	2	\$100	\$200
Training supplies	number of people trained	2	\$82	\$164



The costs of environmental activities must be assigned to the process.

Tables 9 and 10 provide drivers, driver quantities, unit costs, and total annual costs associated with a number of environmental activities for the example current and proposed processes.

Table 9. Resources, Drivers, and Costs for Environmental Activities (Current Process)

ENVIRONMENTAL ACTIVITY	DRIVER	QTY	UNIT COST	ANNUAL COST
1. Compliance audits (internal, external)	Number of waste streams	1	\$30	\$30
2. Documentation maintenance (MSDSs, emergency plans)	Number of waste streams	1	\$30	\$30
3. EHS training (instructor/ contract labor)	Number of workers	2	\$100	\$200
4. EHS training (loss of productive labor)	Number of workers	2	\$1,266	\$2,532
5. EHS training (supplies)	Number of students	2	\$82	\$164
6. Environmental mgmt. plan maintenance (HW Management Plan, Pollution Prevention Plan)	Number of waste streams	1	\$30	\$30
7. Reporting requirements (federal, state, EPCRA/ TRI)	Number of waste streams	1	\$30	\$30
8. Test/Analyze waste streams	Number of waste streams	1	\$750	\$750
9. Sample waste streams	Number of waste streams	1	\$30	\$30
10. Waste disposal (off-site)	Gallons of waste	600	\$3.675	\$2,205
11. Medical exams (medical/contract labor)	Number of exams	1.1	\$200	\$220
12. Medical exams (loss of productive labor)	Number of exams	1.1	\$480	\$528
13. Transport wastes on site (indirect, non-process labor)	Number of drums	12	\$60	\$720
Total	—	—	—	\$7,469

The following tasks are performed to identify or estimate an appropriate cost of each environmental activity associated with the process under study:

- 1. Identify total facility costs for each environmental activity applicable to the process*
- 2. Identify facility resources consumed by each activity*
- 3. Identify the relationship between the activity performed and resource consumed (i.e. driver) Identify the total driver quantity consumed at the facility.*
- 4. Calculate a unit cost for each driver*
- 5. Identify the driver quantity for each resource consumed by the process*
- 6. Calculate the total cost for each resource consumed by the process.*

**Table 10. Environmental Activities
(Proposed Process)**

ENVIRONMENTAL ACTIVITY	DRIVER	QTY	UNIT COST	ANNUAL COST
1. Compliance audits (internal, external)	Number of waste streams	0	\$30	\$0
2. Documentation maintenance (MSDSs, emergency plans)	Number of waste streams	0	\$30	\$0
3. EHS training (instructor/contract labor)	Number of workers	1	\$100	\$100
4. EHS training (loss of productive labor)	Number of workers	1	\$1,266	\$1,266
5. EHS training (supplies)	Number of workers	1	\$82	\$82
6. Environmental mgmt. plan maintenance (HW Management Plan, Pollution Prevention Plan)	Number of waste streams	0	\$30	\$0
7. Reporting requirements (federal, state, EPCRA/ TRI)	Number of waste streams	0	\$30	\$0
8. Test/Analyze waste streams	Number of waste streams	0	\$750	\$0
9. Sample waste streams	Number of waste streams	0	\$30	\$0
10. Waste disposal (off-site)	Gallons of waste	0	\$3.67	\$0
11. Medical exams (medical/contract labor)	Number of exams	1	\$200	\$200
12. Medical exams (loss of productive labor)	Number of exams	1	\$480	\$480
13. Transport wastes on site (indirect, non- process labor)	Number of waste streams	0	\$30	\$0
Total	---	---	---	\$2,128

*Repeat tasks 1-6 for
proposed process of
technology change.*

3.0 ECAM LEVEL III: IDENTIFICATION AND ASSIGNMENT OF OTHER COSTS

The ECAM Level III identifies and assigns other costs (and benefits) associated with the process under evaluation. These include:

- Non-environmental support and overhead costs
- Costs and benefits associated with the impact of the process on productivity.

3.1 Identification and Assignment of Support and Overhead Costs

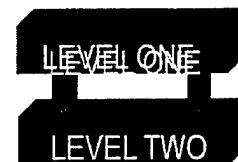
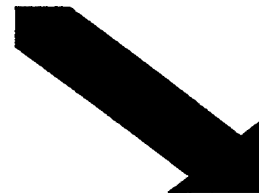
Manufacturing, facility, and general and administrative (G&A) overhead are usually assigned to the process through an allocation mechanism generally based on the proportion of labor hours consumed by the process. These costs are incurred when performing functions that support facility operations, such as human resource management, information technology support, janitorial services, accounting, and facility rent.

The ECAM Levels I and II have greatly improved the degree of precision in assigning such costs, since costs for energy, other utilities, and environmental activities have been assigned using direct or cause-and-effect methods.

After conducting Levels I and II, users should determine if a higher degree of accuracy is required for an appropriate process evaluation.

As a general guideline, other overhead costs should be assigned more precisely only if the ECAM users believe that significant costs associated with the process can still be overlooked, and it is cost effective to analyze such costs. Another reason for not considering these costs in the investment analysis is based on the *with-without principle*. When evaluating an investment, only the cash flows that are different when comparing two alternatives

The ECAM Level III identifies and assigns other costs associated with the process.



Non-environmental overhead costs should be assigned more precisely only if it is cost effective.

are relevant to the decision, and all those that are the same are irrelevant. It is likely that the proposed investment will not cause changes in the expenditures incurred by the human resource department, for example.

Since these cost do not change, identifying these costs is irrelevant to the investment decision.

Once this determination is made, overhead costs can be identified and assigned to the process by following the same procedures described in section 2. The tasks to be completed are similar to those identified for ECAM Level II and are summarized as follows:

- Task One—Build an activities checklist by identifying the activities that support the process but have not been considered in The ECAM Levels I and II.
- Task Two—Identify the resources consumed by such activities.
- Task Three—Identify the costs associated with the activities according to activity-based costing principles, by establishing cause-and-effect relationships and defining activity drivers.
- Task Four—Assign the activity costs to the process by multiplying the driver or quantity consumed by the unit cost associated with the activity.

Again, the incremental value of applying these procedures may be very small depending on the process to be evaluated, and there may be no practical advantage in performing this level of analysis.

3.2 Productivity Costs and Benefits

The proposed technology under evaluation may cause significant impacts on productivity. For example, cycle time can be significantly reduced because of a new technology. This impact may cause significant productivity improvements that should be quantified in order to correctly evaluate the process.

The with-without principle governs the determination of relevant cash flows.

Costs and benefits generated by productivity changes should be identified and assigned.

The ECAM Level III identifies and assigns costs and benefits linked to changes in productivity. This task requires ECAM users to effectively estimate the impact of such productivity changes.

For example, a significant reduction in cycle time for a process that is part of a general logistics process (such as parts repair) causes a reduction in response time, a key logistics productivity parameter. This directly impacts the inventory used to support the process. A reduction in the logistics response time, in fact, would require a lower level of inventory to be carried, if all other conditions remain equal. Lower inventory levels result in lower operating costs, or more precisely, lower inventory carrying costs and lower capital costs. This may represent an extremely significant benefit that should be quantified for an accurate process evaluation.

The quantification of operating costs associated with maintaining a given level of inventory (*inventory holding costs*) can be achieved by considering:

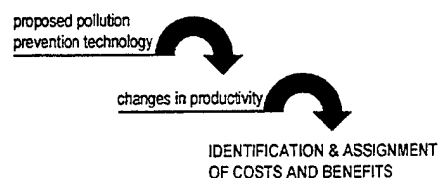
- Opportunity costs
- Storage and warehousing costs
- Obsolescence costs.

Inventory holding costs can be estimated based on guidance provided by the General Accounting Office (GAO).⁴ According to the GAO, annual inventory holding costs may range between 3 percent and 7 percent of the total value of the inventory, with the exception of opportunity costs. Table 11. provides an example of annual savings generated by reductions in inventory holding costs.

Table 11. Potential Annual Savings Generated by Reductions in Inventory Holding Costs

REDUCED CYCLE TIME	INVENTORY VALUE	INVENTORY COSTS	OPPORTUNITY COSTS	POTENTIAL ANNUAL SAVINGS
40%	\$14,543,500	\$581,740	\$509,023	\$1,090,763

⁴ *Defense Inventory - Cost Factors Used to Manage Secondary Items*, GAO Report, May 1992.



The outcome of this task is the identification and assignment of costs and benefits linked to changes in productivity induced by the proposed pollution prevention technology.

4.0 FINANCIAL ANALYSIS

The ECAM Levels I, II, and III generate information to use in making capital investment decisions. A key benefit of The ECAM, compared to other methods, is the availability of more complete and accurate cost information, specifically, environmental costs. This helps the organization to identify any cost savings or expenses that will occur as a result of the proposed investment. The financial analysis can be performed at the conclusion of any level of the ECAM.

Once costs are assigned to the process, environmental investment alternatives are evaluated on the basis of their relative cost or benefit to the organization. The financial data analysis portion of the ECAM includes a *life-cycle cost (LCC)* analysis and a financial analysis that generate financial performance indicators such as *payback*, *net present value (NPV)*, and *internal rate of return*.

This section covers the financial analysis process, assumptions made in this financial analysis model, and steps for conducting an LCC analysis and evaluating economic performance measures.

4.1 Fundamental ECAM Assumptions

The ECAM incorporates specific assumptions consistent with DOD and Office of Management and Budget (OMB) policies. Depreciation is not considered in the ECAM's financial analysis. The DOD expenses its investments in the current budget year. After an investment has been made from the current year's budget, the value of that investment is not depreciated and modified in future years.

The ECAM uses a 15-year study period for evaluating the financial viability of the proposed investment. Analyzing the investment over such a length of time, which is generally longer than that used in traditional

methods, allows organizations to evaluate the real costs and benefits of the proposed technology, as returns on pollution prevention investments are generally longer term. Evaluating the costs of the investment over different intervals can provide the organization with insight regarding the true period in which investment will be recouped. By contrast, simple payback, while providing an important initial picture of the investment, often does not account for out year capital and expenses, and hence does not accurately capture the total costs and benefits to the organization.

Because DOD does not pay state, local, or federal income taxes, taxes are not included in the ECAM financial analysis.

The discount rate to be used in The ECAM is based on guidance offered by the OMB through OMB Circular A-94.⁵ Note that the OMB reference provides both *real* and *nominal* rates for specified time periods, or *maturities*: 3-, 5-, 7-, 10-, and 30-year periods. Real interest rates account for the effect of inflation when conducting financial analyses.

4.2 Life Cycle Cost Analysis

LCC analysis allows users to evaluate the investment correctly by incorporating all costs associated with the entire life cycle of the technology. The LCC analysis incorporates several categories of costs, such as:

- Initial investment
- Capital replacements
- Operating, maintenance, and repair (OM&R) costs, including non-capital replacements
- Energy costs associated with the selected process.

⁵ OMB Circular No. A-94 (Revised), *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Washington DC, October 29, 1992.

The ECAM prescribes a 15-year period for evaluating an investment.



The discount rate used in the financial analysis is identified in OMB Circular A-94.

Life-cycle cost analysis provides a complete investment evaluation.

The ECAM maintains consistency with LCC analysis principles by including all significant costs incurred for each alternative, from inception to abandonment. To accurately account for the principles embodied in LCC analysis, estimates should include the ultimate disposal (through disassembly, recycling, and refurbishment). The LCC analysis is used to rank alternatives on the basis of the life-cycle cost of each alternative. These costs are evaluated over the 15-year period using *discounted cash flow (DCF)* techniques and the recommended OMB discount rate.

Not all technologies result in a reduction in cost over the status quo. In many cases, the technology alternatives available may be more costly than the current process but may be required to meet regulatory or mission critical objectives. In this case, the identification of the alternative with the lowest LCC option is the objective of the ECAM.

4.3 Financial Performance Measures

The three steps in the financial evaluation of investment opportunities include:⁶

- Estimating the relevant cash flows
- Calculating a financial performance measure
- Comparing that measure with an acceptance criterion.

Calculating a financial performance measure requires an understanding of the time value of money and an accurate estimate of relevant cash flows. The following principles govern the determination of relevant cash flows and call for the exercise of judgment and perspective:

The investment is evaluated by estimating the relevant cash flows, calculating a financial performance measure, and comparing that measure with an acceptance criterion.

⁶ R.C. Higgins: *Analysis for Financial Management*, Irwin, Fourth Ed., 1995.

- **The cash flow principle:** Because a dollar received today has greater value than the same dollar received in the future, one should record cash flows in the period they occur. The dollar's value can be lost due to inflation and rising prices, for example.
- **The with-without principle:** Two situations should be compared: one in which the investment is made and one in which the investment is rejected. Cash flows that are different from these two situations are relevant to the decision, and all those that are the same are irrelevant. Only the costs which change are to be considered. Costs which are unchanged can be overlooked; this incremental approach greatly reduces the cost categories to be considered.

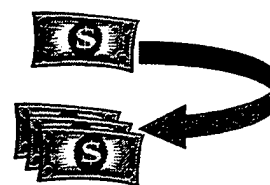
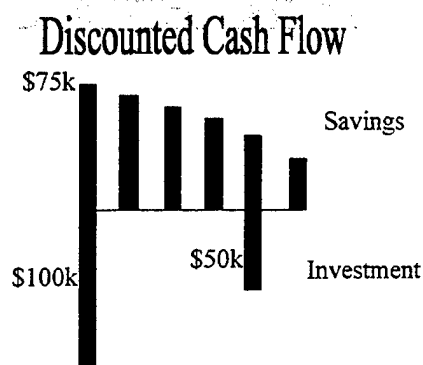
Discounted cash flow (DCF) techniques are at the basis of financial analysis. DCF techniques recognize the time value of money and provide the financial indicators used to make an investment decision: payback period, net present value (NPV), and internal rate of return (IRR).

The following sections define each indicator and discuss its benefits and limitations for use in financial analysis. The ECAM recommends conducting financial analyses that use multiple performance indicators to determine the most viable option.

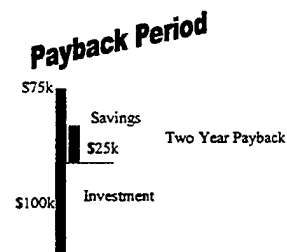
Payback Period

The first step in evaluating a new pollution prevention technology is to calculate simple payback. Simple payback is the time period required to recover 100 percent of investment from future savings. It is calculated by dividing the total project investment by the annual net savings (income) of the project. This is the first indicator to use when evaluating the viability of a proposed investment. It provides an initial view of the project's costs and benefits.

The payback, however, should not be relied on as the sole basis for investment justification because the time value of money is not considered. Payback also does not



The ECAM uses simple payback to provide a preliminary view of the project's costs and benefits.



consider any cash flows that occur after the payback. Looking at payback without NPV can, therefore, lead to the selection of an inferior alternative.

The payback period is a rough measure of investment risk. In most settings, the longer it takes to recover the investment, the greater the risk. This is especially true in high-technology settings in which managers can forecast only a few years into the future.

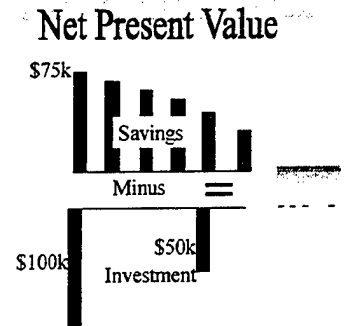
Net Present Value

An accurate figure of investment merit must reflect the notion of the time value of money. The NPV of a given investment is the difference between the present value of cash inflows (savings) and the present value of cash outflows (capital investment.) To calculate NPV, future cash flows are discounted using an appropriate discount rate. (As previously stated, the ECAM uses the discount rate provided in OMB Circular A-94.)

After discounting the cash flows, the initial investment is subtracted to arrive at the project's NPV. NPV calculates both the inflows and outflows associated with the technology. A positive NPV means the project will have an acceptable return. By contrast, a negative NPV illustrates that the project will not have an acceptable return. If a variety of projects are analyzed and multiple positive NPVs are identified, the project with the highest NPV will provide the highest value.

The NPV depends greatly on the discount rate. Using the discount rate to calculate NPV provides a future look at the investment. This helps express the value of a future expenditure in the current year and considers the time value of money (the lost opportunity of being able to invest the money elsewhere) by discounting future cash flows. For example, if two different discount rates are used to evaluate the same investment, the result will be two very different NPVs. The higher the discount rate relative to the other the lower the NPV. Therefore to properly compare technology alternatives the same discount rate is required.

The ECAM uses multiple performance indicators to identify the most viable investment.



Net present value is calculated by the ECAM to provide an accurate financial performance measure for the proposed investment.

Internal Rate of Return

The Internal Rate of Return (IRR) is the discount rate at which the NPV is equal to zero. The IRR may be calculated by looking at the capital costs of the project and the discounted future savings to arrive at a rate of return on the project where the future value of the savings just equals the capital investment. A shortcoming of the IRR is that it does not take into account the total dollar return the way NPV does.

The investment acceptance criterion against which to compare the IRR is the opportunity cost of capital to the organization. The investment is considered to be attractive if its IRR exceeds the opportunity cost of capital. In most instances, the IRR and the NPV yield the same investment recommendations.

Summary of Investment Performance Measures

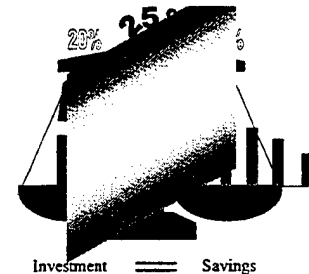
Table 12 can be used as a general guideline for evaluating the viability of a proposed pollution prevention investment.

Table 12. Summary of Investment Criteria

CRITERIA	RECOMMENDATIONS/CONCLUSIONS
NPV > 0	Investment return acceptable
NPV < 0	Investment return not acceptable
Highest NPV	Maximum value to the organization
IRR > discount rate	Project return acceptable
IRR < discount rate	Project return not acceptable
Lowest LCC	Project costs minimized
Shortest payback period	Fastest investment recoup and lowest risk

The ECAM uses internal rate of return as an additional indicator of performance.

The IRR is a process where the discount rate is progressively changed until the discount rate used results in the future savings just equaling the capital investment. That rate used to discount the cash flows is the rate of return earned on the investment.



The option that yields the highest NPV and IRR represents the most preferred investment alternative.

NPV and IRR are the preferred ranking measures because they both consider the time value of money. Payback period is another source of measure; however, it does not consider the time value of money and can overstate the benefits of the investment. The payback period should be used to provide an initial screen of the proposed initiative. In cases in which there are more than one proposed technology, the one with the highest IRR and NPV is the best choice.

Table 13. shows a sample of economic indicators generated by The ECAM. The analyst may wish to conduct a sensitivity analysis of the proposed investment by changing one or more key variables. These scenarios can be used to measure the magnitude of the impact on the financial indicators as a result of change.

Table 13. Sample Summary of Financial Indicators Generated in The ECAM Sensitivity Analysis

REDUCTION	HAZARDOUS WASTE VOLUME REDUCTION		
	100%	75%	50%
NPV	\$137,958	\$93,877	\$59,964
Payback Period	0.8 years	1.2 years	1.7 years
IRR	119%	85%	58%

The financial analysis is facilitated by using P2/FINANCE.

4.4 Final Report Preparation

The ECAM recommends the use of the Pollution Prevention Financial Analysis and Cost Evaluation System (P2/FINANCE) software program to simplify the task of organizing and analyzing cost data, calculating annual cash flows, and generating financial indicators for pollution prevention investments.

The final report should include all supporting documentation according to the ECAM Levels I, II, and III and the results of the financial analysis, preferably presented as the P2/FINANCE program reports.

The P2/FINANCE system is proprietary and copyrighted by Tellus Institute of Boston, Massachusetts. It is provided, free of charge, by the U.S. Environmental Protection Agency as a service to government organizations performing financial analysis of pollution prevention projects. Appendix C provides a description of P2/FINANCE and an example of its application. P2/FINANCE software and the User's Guide may be obtained by ordering directly from the EPA Pollution Prevention Information Clearinghouse (PPIC) web site: <http://www.epa.gov/opptintr/p2home/ppicdist.htm> (under the "Design for the Environment (DfE)" section). Orders may also be placed by calling the PPIC at (202) 260-1023.

5.0 QUALITATIVE ISSUES

The decision to invest in a pollution prevention technology should not be based entirely on financial analysis. Certain qualitative issues must also be considered. Equally important are the public relations benefits that come with implementing pollution prevention technologies, and the potential reductions in financial and criminal liability.

Although qualitative issues remain largely unexamined in most environmental investment decisions, they can be identified and communicated to decision makers as added benefits of project implementation. The following sections address product quality, public image, potential liability, and employee health and safety issues that

The ECAM final report includes documentation on The ECAM Levels I, II, and III and the outcome of the financial analysis.



Qualitative issues, such as product quality, community image, and potential liability, play a role in the decision-making process.

should be examined during the decision-making process. Methods for estimating the costs of these criteria are also discussed.

5.1 Product Quality

Product quality is a critical component in the decision-making process. Projects that appear attractive financially but do not provide the desired quality cannot be considered. A technology that adversely impacts a product can decrease productivity and jeopardize mission requirements. Examples exist of green technologies that reduced pollution and made financial sense to the organization but later exhibited adverse impacts on product quality.

Each project evaluation should consider the impacts of the new technology on similar products. Adequate research and pilot-scale investigation can show preliminary benefits or costs of the proposed technology on product quality. Consideration must be given to the specifications, standards, and technical order requirements that will be affected by the proposed technology.

In some cases, implementing new technologies can enhance product quality, and although these factors are not quantified in the ECAM, they can be communicated to decision makers as additional benefits of investment.

Productivity can be affected significantly by pollution prevention investments. Proposed pollution prevention technologies may reduce cycle time dramatically lowering labor costs. These improvements in productivity are captured in the ECAM and are integral to the financial analysis.

Productivity can also be negatively impacted by technology investments. Some process changes can reduce pollution, but increase cycle time or even require more labor than the current process. These are also identified during the process analysis and cost calculations. Negative impacts will be calculated by the ECAM and should be identified as potential disadvantages to the proposed investment.

- *System enhances product quality*
- *System improves mission readiness and weapons system effectiveness through improved product quality*

The technology's impact on product quality can be used to screen various options from consideration.

The impacts of investments on process efficiency, and employee productivity should be considered in the decision-making process.

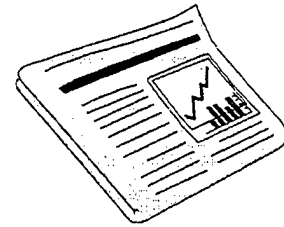
5.2 Public Image

It is difficult to quantify the benefits of an improved community image, or that of a "green" organization. Negative publicity, however, costs money. Increased public affairs expenditures can occur, and regulatory authorities are likely to pay more attention to facilities that must devote additional labor resources to maintain compliance. Some of the costs associated with a negative community image can be estimated, although the degree of accuracy will vary depending on the availability of the collected data and the assumptions used in the estimation.

One method of quantifying these costs is to analyze the resources expended on public relations resulting from fines associated with disposal and non-compliance issues. Costs can occur as labor and material expenditures associated with publications (press releases, newspaper articles, television interviews, responding to public information requests). Costs can also be quantified by evaluating the amount of time an organization's personnel spend with regulatory authorities responding to information requests and conducting facility inspections. In addition, a "noncompliant" organization may invest more time in internal compliance activities than a "compliant" organization, resulting in additional resource requirements. Implementing a pollution prevention technology that improves the community image can provide less tangible benefits, as well as cost avoidance.

By the same token, positive news stories about the savings and benefits of new investments can also be quantified and considered in the investment analysis. Costs could include associated labor, material and production costs for items, such as newsletters and press releases, and associated communication and distribution costs.

The added benefits of the improved community image associated with implementing a pollution prevention project, especially if the project is focused on a process that is perceived by the public to be an environmental problem should be explained to decision makers.



Improving public image can be an added benefit of many pollution prevention investments.

- *System implements pro-environment technology*
- *Facility can publicize environmental benefits of investment*
- *System serves as a case study for environmental engineering students at local university*

Cost avoidance related to financial and criminal liabilities is part of the ECAM process.

5.3 Potential Liability

Implementing pollution prevention technologies can also offer significant benefits in the form of avoided costs.

Cost avoidance can be achieved in areas such as remediation, employee claims, and regulatory fines. For example, investing in a pollution prevention technology that eliminates a waste stream can reduce future liabilities associated with cleanup (remediation) of a site where that waste stream was deposited. In addition, cost-estimating tools are available for predicting cost avoidance related to penalties and fines; however, these tools vary in accuracy. Some of these tools are described below.

Unit Cost Estimates

This method is based on the availability of reliable historical data on comparable sites. The total reported cost equals the amount of waste multiplied by the unit cost to dispose of the waste or to remediate the site. For example:

Soil Contamination Cost = Volume of Contaminated Soil x Cost per cubic yard to excavate and dispose of the soil

Ground Water Contamination Cost = Volume of Contaminated Water x Unit Volume Treatment Cost (+ Oversight and Monitoring Costs)

Air Emissions Costs = Number of Stacks x Cost of emission control device per stack

Probabilistic Cost Estimates

This method relies on estimating the probability of a certain event or outcome. The reported total cost is equal to the cost associated with a certain outcome multiplied by the probability of the occurrence of that outcome. For example, if a storage tank has an estimated probability of leaking equal to 10 percent:

System Advantages:

- *Eliminates hazardous waste generation to air, land, and water*
- *Reduces/eliminates hazardous waste/hazardous material storage and accumulation area maintenance*
- *Reduces hazardous waste transportation*
- *Eliminates hazardous waste landfill disposal needs*
- *Assists facility with closing a NPDES discharge violation by reducing wastewater discharges to within compliance levels*

Storage Tank Spill Cost = 10 Percent of Total Costs of Emergency Response and Remediation.

If financial estimation methods are not used, these issues should be explained to management as additional benefits associated with project implementation.

5.4 Employee Health and Safety Considerations

Employee health and safety considerations must also be factored into the investment analysis. Improving working conditions and reducing personal protective equipment costs are beneficial to the decision-making process. For example, improved working conditions result in reduced worker injury claims and resulting health care payments; increased employee productivity; and minimized regulatory oversight and fines.

Certain types of health and safety costs can be applied universally, regardless of the organization or technology. These costs can be evaluated by:

- Comparing existing worker exposure costs of current and proposed technologies
- Estimating increases in employee absenteeism in terms of lost resources
- Estimating improvements in the employee turnover rate and training of new staff
- Estimating the savings from reduced personal protective equipment requirements.

If health and safety costs are quantified, these costs can also be captured by the ECAM.

System Advantages:

- *Reduces potential for worker health and safety exposure*
- *Reduces PPE requirements*
- *Reduces medical surveillance and examination requirements*

GLOSSARY

ACTIVITY is a unit of work that has identifiable starting and ending points, that consumes *resources* (inputs) and produces *outputs*. In activity-based costing, an activity is synonymous with a simple *process*, as the latter term is used in quality management and reengineering.

ACTIVITY-BASED COSTING (ABC) is a means of creating a system that ultimately directs an organization's costs to the processes, products and services that required these costs to be incurred. Using ABC, costs are traced to processes, products and services by identifying causal relationships between activities and incurred costs.

ACTIVITY DRIVER is a factor that describes the cause-and-effect relationship between the activity and the cost incurred to perform the activity.

CASH FLOW PRINCIPLE is based on the idea that because money has a time value, one should record cash flows when the money is actually received or expensed.

CONVENTIONAL COSTS include costs typically recognized in capital budgeting exercises such as capital equipment, raw materials, supplies and equipment. Referred to as *usual costs* in EPA's *Pollution Prevention Benefits Manual*.

CONTINGENT COSTS refer to environmental costs that are not certain to occur in the future but depend on uncertain future events (e.g., costs of remediating future spills). Sometimes referred to as "environmental liabilities," "liability costs," or "*contingent liabilities*."

DIRECT COSTS is an accounting term for costs that are clearly and exclusively associated with a product or service and treated as such in cost accounting systems.

DISCOUNT RATE (R) is the interest rate in present value calculations. The discount rate represents the rate of return that the organization could earn on alternative investments. An organization may have a minimum required rate of return (or hurdle rate) which investments must exceed (e.g., 15 percent). Investments which do not generate an *Internal Rate of Return (IRR)* of 15 percent or do not generate a positive *Net Present Value (NPV)* when discounted at the hurdle rate, do not provide the organization's required rate of return.

DISCOUNTED CASH FLOW (DCF) refers to a family of techniques for analyzing investment opportunities that take into account the time value of money.

DISCOUNTED PAYBACK is the time period within which the discounted future savings of a project repay the Initial Investment Costs. Discounted Payback does not account for cash flows that occur after the payback period.

ENVIRONMENTAL COSTS refer to costs incurred by an organization to comply with environmental laws, costs for environmental protection, costs of environmental remediation, or other such costs. The definition of environmental costs may vary across different organizations. Environmental

costs can be categorized as conventional (associated with capital equipment, labor, materials, etc.), potentially hidden (upfront and back-end costs, regulatory costs, voluntary costs), contingent, and less tangible (image and relationship costs). Environmental costs can also be external costs (*societal costs*).

ENVIRONMENTAL LIABILITIES refers to different types of environmental costs including future costs for remediating existing contamination, potential costs of complying with new regulations, future environmental costs of current operations (also known as *back-end* or *exit costs*), and/or *contingent costs*.

FLOW DIAGRAM is a visual representation of the overall *process*, using information gathered on-site.

FUTURE (OR PROSPECTIVE) COSTS refer to environmental costs that are certain to be incurred at a later date, which may or may not be known. Sometimes referred to as "environmental liabilities."

HIDDEN COSTS refer to the results of assigning environmental costs to overhead pools or overlooking *future* and *contingent costs*.

INTERNAL COST is a synonym for private costs.

INTERNAL RATE OF RETURN (IRR) is the discount rate at which the investment's NPV equals zero. The corresponding acceptance criterion against which to compare the IRR is the opportunity cost of capital to the organization. If the investment's IRR exceeds the opportunity cost of capital, the investment is attractive, and vice versa.

LESS TANGIBLE COSTS refers to expenses incurred for corporate image purposes or for maintaining or enhancing relationships with regulators, customers, suppliers, host communities, investors/lenders, and the general public.

LIFE CYCLE COSTING is a costing concept that includes all the costs incurred for a product, from its inception to abandonment, as part of its product cost. This could include cost of extraction, intermediate manufacturing, manufacturing, transportation, product recycling in take-back, disassembling, reverse distribution, restocking used material, disposing of waste, etc.

MATERIALS BALANCE refers to an organized system of accounting for the flow, generation, consumption, and accumulation of materials in a facility or process in order to identify and characterize waste streams. Some view a materials balance as a more rigorous form of materials accounting. The Labor, Materials & Energy Balance used in The ECAM accounts not only for materials, but for all resources, which includes labor, materials, and utilities.

NET PRESENT VALUE (NPV) is the project's *present value* of all future cash flows, less the initial cost. Projects with a positive net present value have cash flows in excess of the initial investment (i.e., the difference between the cash inflows and cash outflows is greater than zero).

NPV = Present value of cash inflows – Present value of cash outflows

NET PRESENT VALUE SAVINGS is the additional NPV savings identified using The ECAM which exceeds the traditional economic analysis approaches. NPV savings represent the incremental change in identified savings [expressed in **Present Value (PV)** dollars] over traditional approaches.

NOMINAL INTEREST RATE is the interest rate observed in the market, composed of two elements: the real interest rate and the expected inflation rate.

OPPORTUNITY COST is the return one could earn on the next best investment alternative. Because there are always productive opportunities for investment dollars, all investments involve opportunity costs.

OUTPUTS are products and services (including work-in-progress) that flow out of an activity or process, and information about them.

OVERHEAD is often used synonymously with *indirect* or *hidden* costs as comprising all costs that are not accounted for as the *direct* costs of a particular process, system, product, or facility. The underlying distinction is between (1) costs that are either pooled and allocated on the basis of some formula, or not allocated at all, and (2) costs that an accounting system treats as belonging (directly) to a process, system, product, or facility (i.e., a cost center, in accounting terminology).

PAYBACK PERIOD (P/B) is the length of time required to recoup the initial investment. Simple Payback periods do not consider the time value of money.

$$P/B = \text{Initial Capital Investment} / \text{Annual Cash Inflow}$$

PRESENT VALUE (PV) is the value of future cash flows in today's dollars (i.e., current or present dollars). Savings (income) earned in future years is less valuable than dollars today, therefore future dollars are discounted by an interest rate representing the opportunity cost of recognizing future savings (income). The **discount rate** or interest rate is the required rate of return (i.e., hurdle rate, cost of capital, or financing/borrowing rate).

PRIVATE COSTS are costs that a business incurs or can be held responsible for. These are the costs that directly affect a firm's bottom line. Private costs are sometimes termed *internal* costs.

PROCESS is a set of logically related activities performed to achieve a defined business outcome, such as to produce a product or service.

PROCESS BOUNDARIES define the scope of the analysis.

REAL INTEREST RATE is the interest rate that would occur with no inflation. The real interest rate is composed of a risk-free interest rate plus a risk premium.

RESOURCES include money, labor, material, supplies, and other economic elements consumed by activities to produce outputs.

RESOURCE DRIVER 1) A factor used to assign cost to activities. 2) A measure of the quantity of resources consumed by an activity. An example of a resource driver is the percentage of total square feet of space occupied by an activity. This factor is used to allocate a portion of the cost of operating the facilities to the activity.

SOCIETAL COSTS are the costs of a company's impacts on the environment and society for which the business is not financially responsible. These costs do not directly affect a firm's bottom line. Societal costs may also be referred to as *external costs* or *externalities*. These costs may be expressed, qualitatively, in physical terms (e.g., tons of releases, exposed receptors), or in dollars and cents. Societal costs (or externalities) are sometimes subdivided according to whether the impacts are environmental, referred to as environmental costs or environmental externalities, or social, referred to as *social costs* or social externalities.

WITH-WITHOUT PRINCIPLE According to this principle, two situations should be compared when making an investment decision: one in which the investment is made and one in which the investment is rejected. All cash flows that are different in these two settings are relevant to the decision, and all those that are the same are irrelevant.

BIBLIOGRAPHY

- Benchmarking: The Primer, Benchmarking for Continuous Environmental Improvements.* Washington, DC: Global Environmental Management Initiative, 1994.
- Butner, R. S. *Development of a Material Balance Methodology: Guidance for Performing Material Balances in AMC Industrial Facilities.* Report no. PNL-8273. Richland, WA: Battelle Memorial Institute, Pacific Northwest Laboratories, August 1992.
- Cokins, G., A. Stratton, and J. Helbling. *An ABC Manager's Primer.* Montvale, NJ: Institute of Management Accounts, 1993.
- Demery, Paul. *Learning the ABCs of Targeted Profitability.* Practical Accountant, vol. 30, March 1997. p. 14.
- Department of the Army Cost Analysis Manual.* Washington, DC: U.S. Army Cost and Economic Analysis Center, August 1992.
- Dilley, Steven C, Jacobs, Fred H. and Marshall, Ronald M. *The Tax Benefits of ABC.* Journal of Accountancy, vol. 183, March 1997. pp. 34-37.
- Ditz, D., J. Ranganathan, and R. D. Banks (eds.). *Green Ledgers: Case Studies in Corporate Environmental Accounting.* Washington, DC: World Resources Institute, 1995.
- Environmental Life Cycle Costing Project SADARM.* Huntsville, TX: Sam Houston State University, College of Business Administration, September 10, 1995.
- Epstein, Marc J. *You've Got a Great Environmental Strategy - Now What?* Business Horizons, vol. 39, September-October 1996. pp. 53-59.
- Epstein, Marc J. *Improving Environmental Management with Full Cost Accounting.* Environmental Quality Management Journal, vol. 6, Autumn 1996. pp. 11-22.
- General Accounting Office. *Defense Inventory - Cost Factors Used to Manage Secondary Items.* May 1992.
- Guide for Conducting an Environmental Baseline of DOD Industrial Operations.* Draft Report. Johnstown, PA: Concurrent Technologies Corporation, National Defense Center for Environmental Excellence, (no date).
- Higgins, Robert C. *Analysis for Financial Management* (Fourth Ed.). Irwin, 1995.
- Kehoe, J., et al. *Activity-Based Management in Government.* Coopers & Lybrand, L.L.P. Mansfield, OH: Bookmasters, Inc., 1995.
- Kroll, Karen M. *The ABCs Revisited.* Industry Week, vol. 245, December 2, 1996. pp. 19-21.

ENVIRONMENTAL COST ANALYSIS METHODOLOGY (ECAM) HANDBOOK

Manufacturing and Maintenance Process Cost Analysis Tool (M2PCAT). Draft Data Report.
Fairfax, VA: Parsons Engineering Science, Inc., February 1996.

O'Guin, M. *The Complete Guide to Activity-Based Costing*. New Jersey: Prentice Hall, 1991.

P2/FINANCE Version 3.0 in Microsoft Excel Version 5.0 for Windows. Report no. EPA 742-B-96-008. Boston: Tellus Institute, 1996.

Srikumar, Rao S. *ABCs of Cost Control*. Inc. Journal, vol. 19, June 17, 1997. pp. 79-81.

Srikumar Rao S. *Overhead Can Kill You*. Forbes, vol. 159, February 10, 1997. pp. 97-98.

Stakeholders' Action Agenda: A Report of the Workshop on Accounting and Capital Budgeting for Environmental Costs (December 5-7, 1993). Report no. EPA 742-R-94-003. Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, May 1994.

U.S. Environmental Protection Agency. *Federal Facility Pollution Prevention Project Analysis: A Primer for Applying Life Cycle and Total Cost Assessment Concepts*. 300-B-95-008. Washington, DC, July 1995.

U.S. Environmental Protection Agency. *An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms*. EPA742-R95-001, Washington, DC, June 1995.

U.S. Environmental Protection Agency. *Making Solid (Waste) Decisions With Full Cost Accounting*. EPA 530-K-96-001, Washington, DC, June 1996.

Vogel, David W. *Understanding Environmental Cost is Key to Improved Business Performance*. Management Accounting, vol. 78, March 1997. p. 66.

Zimmerman, Jerold L. *Accounting for Decision Making and Control*. Irwin, 1995.

APPENDIX A ECAM SUMMARY

ECAM LEVEL I

Item	Description	Reference(s)	Comments
1.	Identify and define the process.	Section 1.1, Appendix B-1	Identify the current and proposed processes to be evaluated, and define their boundaries. Describe each process, including key differences between the two.
2.	Develop overall process flow diagrams.	Section 1.2, Appendix B-2	Develop overall process flow diagrams using templates in Appendix B-2 for the current and proposed technologies.
3.	Identify capital costs.	Section 1.5, Appendix C (P2/FINANCE example worksheet, <i>Initial Investment Costs</i>)	Identify capital costs associated with the current and proposed processes.
4.	Identify the steps of interest within the overall process flow diagram	Section 1.2	Select steps within the overall process flow diagrams that will be most significantly affected by changing from the current to proposed technologies. Only these steps will be more closely evaluated. Possible sources for this information include process-level personnel, direct observation of the process, existing process flow diagrams, owner's manuals, equipment schematics, and drawings.
5.	For steps identified in Item 4, identify direct activities (including environmental). Enter the list of activities in Table 2.	Section 1.3, Table 2	Identify direct activities (including direct environmental activities) associated with each step identified in Item 4. Enter each activity in Table 2. Possible sources for this information include process-level personnel, direct observation of the process, existing process flow diagrams, owner's manuals, equipment schematics, and drawings.
6.	Identify resources consumed by each activity identified in Item 5. Enter results in Table 2.	Section 1.3, Table 2, Appendix B-3	Possible sources for this information include process-level personnel, direct observation of the process, process flow diagrams, owner's manuals, equipment schematics, and drawings.
7.	Identify units of measure (drivers) for each resource identified in Item 6. Enter results in Table 3 or 1-4	Sections 1.4 and 2.3, Table 3 and 4	In cases where a unit of measure is not obvious, a close approximation or estimate may be used. It should be based on a cause-and-effect relationship.

ECAM LEVEL I

Item	Description	Reference(s)	Comments
8.	Quantify the annual consumption of each resource identified in Item 6.	Section 1.4, Table 3 and 4	Possible sources for cost information include invoices, engineering estimates, annual budget reports, accounting reference material, other cost or studies, vendor quotes, price lists, the Government Service Acquisitions (GSA) schedule.
9.	Determine the unit costs for each resource identified in Item 6.	Section 1.4, Table 3 and 4	Identify the cost associated with each.
10.	Determine the annual cost for each resource identified in Item 6.	Section 1.4, Table 3 and 4	For each resource, multiply the values obtained in Item 8 with the corresponding values in Item 9.
11.	Develop an Input/Output diagram for each step identified in Item 4.	Section 1.3, Figure 4	This item may be completed in parallel with Items 4 through 11. In fact, Input/Output diagrams may be useful tools for collecting other data needed in Items 4 through 11.
END OF ECAM LEVEL I			

ECAM LEVEL II

Item	Description	Reference(s)	Comments
12.	For processes identified and defined in Item 1, identify indirect and hidden environmental activities.	Section 2.1, Table 5	See comments corresponding to Item 1, above.
13.	Repeat Items 6 through 10 for each indirect/hidden environmental activity identified in Item 12.	Sections 2.2 through 2.4, Tables 6 through 10	See comments corresponding to Items 6 through 10, above.
END OF ECAM LEVEL II			

ECAM LEVEL III			
Item	Description	Reference(s)	Comments
14.	For processes identified and defined in Item 1, identify other overhead activities.	Section 3.1, Table 11	See comments corresponding to Item 1, above.
15.	Repeat Items 6 through 10 for each overhead activity identified in Item 14.	Section 3.2	See comments corresponding to Items 6 through 10, above.
END OF ECAM LEVEL III			

ECAM FINANCIAL ANALYSIS			
Item	Description	Reference(s)	Comments
16.	Perform financial analysis using P2/FINANCE.	Sections 4.1 through 4.4 Appendix C, P2/FINANCE User's Manual	The NPV, IRR, and Payback Period should be reported. All assumptions should be clearly stated.
17.	Identify qualitative issues associated with the processes identified in Item 1.	Section 5 (all)	Qualitative items associated with the current and proposed technologies should be clearly listed. Possible sources for this information include environmental engineers, process-level personnel, equipment vendors, local/state/federal environmental agencies.
END OF ECAM			

APPENDIX B-1 DATA COLLECTION FORMS

GENERAL FACILITY QUESTIONS**1. POINTS OF CONTACT**

Please provide two points of contact for each of the following organizational areas. For each point of contact, indicate their name, organizational unit, phone number, and electronic mail address so that we may contact them to request additional information and schedule on-site interviews.

Overall Facility/Organizational Management

Name/Organizational Unit	Phone Number	E-mail

Accounting Department

Name/Organizational Unit	Phone Number	E-mail

Engineering Operations

Name/Organizational Unit	Phone Number	E-mail

Environmental Department

Name/Organizational Unit	Phone Number	E-mail

Other Relevant Points of Contact

Name/Organizational Unit	Phone Number	E-mail

2. ORGANIZATIONAL INFORMATION

In order for us to gain a better understanding of your organization and its structure, please provide us with the following documents.

Organizational Overview - Documents that provide a summary of facility operations. For example, the facility's mission statement, strategic plan, and/or marketing brochure.

Organization Chart - A high-level organization chart for the entire facility.

3. EMPLOYEE INFORMATION

To assist in understanding the scope of your operations, please provide information on the total number of people working at the facility and, if available, a break out of the number of people by organizational unit.

4. FACILITY LAYOUTS

Please provide us with an existing high level layout of the facility, including, if possible, square footage information. In particular, please provide any existing floor plans for the building where the (state type of) operations are performed.

PROCESS INFORMATION

1. PROCESS FLOW

If available, please provide us with any existing process flow charts describing both the previous (state type) operations and the new (state type) operations with the technology (state technology name) installed. Example process flow charts are provided to indicate the type of materials and energy balance information desired. In addition, please provide any prior reports, studies or evaluations relating to the process.

2. ENVIRONMENTAL, HEALTH AND SAFETY INFORMATION

Please provide any existing documents describing the environmental, health and safety activities performed in relation to the plating acid bath process. This should include procedures for handling, storing, and disposing of hazardous substances.

3. JOB DESCRIPTIONS

Please provide job descriptions for the personnel involved in the (state type) operations.

ACCOUNTING INFORMATION

1. ACCOUNTING SYSTEM

Please provide information about your current accounting system(s). Describe the systems in terms of the Funds under which you operate (e.g., DWCF, General Fund, Trust Fund, etc.), as well as the accounting system (e.g., NIFMS, SIFS, or STARS). (Please indicate the system's query capabilities and whether the results are available in electronic format.)

2. BUDGET FORECASTING

Please provide budget forecast information for the current fiscal year and at least one outyear.

3. GENERAL FINANCIAL INFORMATION

To help us identify the full cost of operations, please provide us, if available, with the following information:

- a) A list of your sources and obligations of funds for the current fiscal year.
- b) A printout of your General Ledger expense accounts. If your system does not correspond with the DOD Standard General Ledger please provide account descriptions.
- c) Departmental reporting information indicating expenses by organizational unit (Managerial Accounting Data).

4. CAPITAL EQUIPMENT INFORMATION

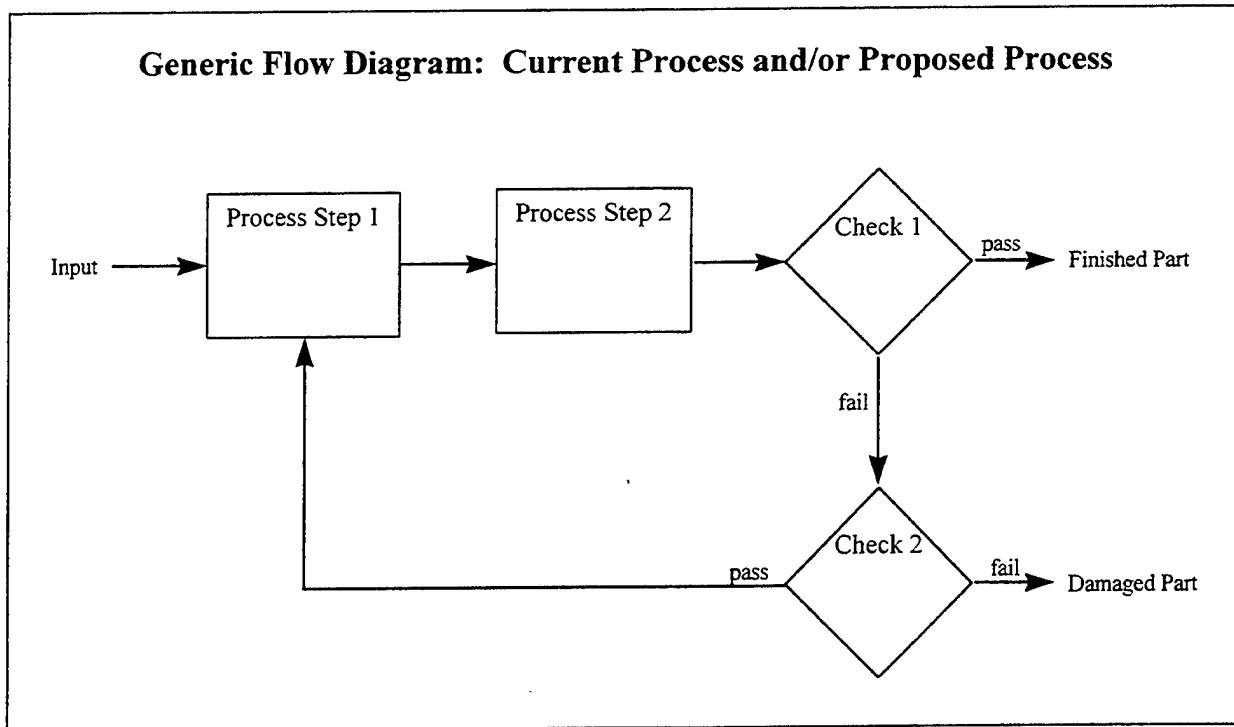
Please provide information on the cost of major equipment required for the (state technology name).

- a. For equipment that has been capitalized, provide detail of the associated depreciation expense calculation.
- b. For major equipment that was expensed, provide the following:

Date of Acquisition
Purchase Price
Useful Life

APPENDIX B-2

BLANK PROCESS FLOW DIAGRAM



APPENDIX B-3

BLANK INPUT/OUTPUT DIAGRAM

Generic Input/Output Diagram/Data

Labor

Number of Operator(s): _____

Hours/day: _____

Days/year: _____

Utilities

Electricity: _____ kWh/hr

Water: _____ gal/day

Gas: _____ MCF/day

Materials/Parts/Components

Description | Amt/day | Amt/year

Process Step #: _____

Equipment Name | Capacity

Finished Parts/Components

Description | Amt/day | Amt/year

Non-hazardous Material Outputs

Description | Amt/day | Amt/year

Air Emissions: _____

Water and Liquids: _____

Solids: _____

Hazardous Material Outputs

Description | Amt/day | Amt/year

Air Emissions: _____

Water and Liquids: _____

Solids: _____

APPENDIX B-4

ENVIRONMENTAL ACTIVITIES CHECKLIST

ENVIRONMENTAL ACTIVITIES CHECKLIST

The table below presents a broad list of environmental activities that are generally performed in an operating facility. For each broad activity, specific activities are also suggested as an example. Additions to the list can be provided as needed. Although each facility is different, the *Broad Activity Categories* can be ranked as follows, with 1 representing the highest potential opportunities for savings.

1. Support Facility Operations
2. Operate/Maintain Equipment and Facilities
3. Other (Subcontracts, Special Projects, etc.)
4. Provide and Administer Training
5. Obtain and Maintain Permits
6. Develop and Maintain Documentation

List of Environmental Activities

BROAD ACTIVITY CATEGORY	SPECIFIC ACTIVITY
Support Facility Operations	Test equipment for proper use
	Conduct emergency drills
	Perform internal audits (compliance, etc.)
	Comply with external audit requirements
	Oversee environmental audits by external agency
	Treat on-site waste
	Transport of on-site and off-site waste
	Dispose of hazardous waste/material
	Maintain accumulation point/hazardous material storage
	Oversee hazardous waste accumulation point management
	Maintain insurance for hazardous waste contractors
	Label hazardous waste containers
	Complete hazardous waste manifest requirements
	Handle hazardous materials

ENVIRONMENTAL COST ANALYSIS METHODOLOGY (ECAM) HANDBOOK

BROAD ACTIVITY CATEGORY	SPECIFIC ACTIVITY
Operate/Maintain Equipment and Facilities	Purchase and maintain personal protection equipment
	Purchase and maintain facility equipment
	Order, receive and distribute EHS supplies
	Operate solid waste equipment/facilities
	Operate liquid waste/wastewater equipment/facilities
	Operate air emission treatment equipment
	Purchase and store drums and labels
	Purchase and store handling and shipping materials
	Perform sampling and analysis
	Provide medical exams
	Dispose of waste off-site
	Provide insurance on equipment
	Evaluate environmental projects (pollution prevention, remediation, etc.)
	Develop and implement environmental management systems (ISO 14000, etc.)
	Provide waste disposal contractor insurance
Provide and Administer Training	Provide safety (rights, awareness, hazard prevention, protection) training
	Provide training for on-site emergency medical staff
	Provide environmental training
	Provide hazardous material training to managers
Obtain and Maintain Permits	Obtain and maintain Clean Air Act permits
	Obtain and maintain Clean Water Act permits
	Obtain and maintain Resource Conservation and Recovery Act permits
	Obtain and Maintain SARA (hazardous material generator) permits

BROAD ACTIVITY CATEGORY	SPECIFIC ACTIVITY
Develop and Maintain Documentation	Create and maintain MSDS forms
	Prepare spill/release emergency plans
	Prepare accident plans
	Perform internal industrial hygiene survey/report
	Oversee industrial hygiene audit by external agency
	Develop employee duties/responsibilities/procedures
	Prepare TRI reports
	Prepare EPCRA reports
	Prepare State reports
	Develop and maintain programs and procedures
	Develop and maintain strategic plans and budgets
	Prepare container labels
	Fill manifest forms
	Prepare supply orders

The following questions help in obtaining additional relevant information on the environmental activities performed at the facility.

SUPPORT FACILITY OPERATIONS

Do you have internal audit teams?
How many employees are involved?
From which departments?
Do you spend time developing audit checklists and documentation?
Do you produce reports?
How many internal audits do you conduct per year?
How much time is needed to complete an audit?
Do you conduct emergency drills?
Is it part of the audit?
Do you treat waste on-site?
What is your waste production by waste stream?
What processes produce a significant amount of waste?
How much space is occupied by temporary waste storage areas?
Is waste disposed of on-site?
Are contractors involved?
What is the contract cost?
Do you incur transportation costs for off-site disposal?
How many employees participate in waste treatment and disposal operations?
How much space is occupied by hazardous material storage areas?
How long are hazardous materials stored for?
Do you dispose of unused hazardous material?
How many employees are dedicated to on-site hazardous material handling, transportation, and storage?

OPERATE/MAINTAIN EQUIPMENT AND FACILITIES

What type and quantity of personal protection equipment do you purchase and maintain (goggles, gloves, respirators, etc.)? What is the cost?
What type and quantity of facility safety equipment do you purchase and maintain (fire extinguishers, ventilation, etc.)? What is the cost?
How many employees are involved in operation and maintenance of environmental equipment and facilities?
What is the cost of purchasing and storing hazardous material drums, labels, handling and shipping material?

OTHER (SUBCONTRACTS, SPECIAL PROJECTS, ETC.)

What activities listed in the previous table are applicable to your facility?
How many employees are involved?
Which activities are provided by contractors?
What are the insurance costs?
Do you perform any other activities not listed in the table?

PROVIDE AND ADMINISTER TRAINING

What type of specific training do you provide?
Is training provided through in-house resources or do you have contractor-provided training courses?
How many employees have instruction duties?
What is the cost of providing external training?
How many employees have attended training during the last fiscal year?
Do you have a breakdown by department/organizational unit?
Is there a required amount of training hours per employee?
Did you incur any significant cost for training materials?
Are personnel involved in developing training material?

OBTAIN AND MAINTAIN PERMITS

How many permits do you maintain in the different areas?
How many employees are involved?
What are the fees associated with each permit?

DEVELOP AND MAINTAIN DOCUMENTATION

How many employees are assigned to the different specific activities?
How many days are spent in preparing reports?
What are the efforts that generate the most significant workload (TRI reports, programs and procedures, etc.)?

APPENDIX B-5

CHECKLIST OF QUALITATIVE ENVIRONMENTAL FACTORS

Qualitative Environmental Factors

CATEGORY AND ACTIVITY LIST	CURRENT	PROPOSED
Product Quality:		
• System meets product quality specifications		
• System enhances product quality		
• Other (list):		
Liability:		
• System eliminates hazardous waste generation to air, land, and water		
• System reduces/eliminates hazardous waste/hazardous material storage/accumulation area maintenance		
• System reduces hazardous waste transportation, discharge		
• Other (list):		
Community Image:		
• System implements pro-environment technology		
• Facility can publicize environmental benefits of investment		
• Other (list):		
Worker Health and Safety:		
• System reduces potential for worker health and safety		
• System reduces PPE requirements		
• Other (list):		

APPENDIX C P2/FINANCE OVERVIEW AND APPLICATION

P2/FINANCE OVERVIEW

P2/FINANCE is a proprietary software tool that is provided to the U.S. EPA as a service to government organizations to facilitate the financial analysis of pollution prevention projects. The system has been developed and copyrighted by Tellus Institute in Boston, Massachusetts. An on-line help system is available in P2/FINANCE, and detailed guidance is available in the User's Guide. This appendix discusses some of the basic data entry parameters within the tool, and presents examples of completed investment projects.

The P2/FINANCE software simplifies the task of organizing and analyzing cost data, calculating annual cash flows, and generating figures of merit for pollution prevention investments. P2/FINANCE comparisons measure the operating costs of the current process against those of an alternative process and include capital costs (e.g., equipment, materials, utility connections, site preparation) and operating costs. P2/FINANCE treats the current equipment as a sunk cost with a zero dollar value, with an assumed zero-dollar salvage value.

P2/FINANCE allows development of up to two alternative financial analyses. With user inputs, the tools can also create a baseline scenario, which contains data on "business-as-usual" operations. The financial analyses for each alternative are compared to the baseline to calculate incremental cash flows and profitability analyses over various project lifetimes.

To use P2/FINANCE, one must obtain data on the specific scenarios. As stated in the ECAM Handbook Section 4, one must also include the discount rate to account for the opportunity cost of using the money for the investment. The discount rate is identified in OMB Circular No. A-94. To maintain consistency with ECAM and DOD principles, P2/FINANCE data entries for inflation rate, tax, and depreciation should be equal to zero.

P2/FINANCE allows one to specify a default investment year for each scenario, from which Annual Operating Costs are calculated. The tool also requires designation of the project lifetime for each scenario to define the end year for the Annual Operating Costs, and an initial investment cost.

P2/FINANCE also calculates a scenario summary which depicts the scenario as it was defined by the user without performing any of the calculations or inflating any of the values, lists the parameters of the cost categories and the default parameters for each scenario.

Annual operating costs and incremental profitability analysis are also calculated. On the annual operating costs sheet for the scenario one should enter the annual operating costs, including, for each cost category, the name of the category, escalation, start year, and end year.

The following pages present a sample from a completed P2/FINANCE package used to complete an ECAM application. A brief discussion on conducting a sensitivity analysis on investment options is also provided below.

SENSITIVITY ANALYSIS

A sensitivity analysis can be conducted to evaluate the impact on economic indicators when assumptions regarding the investments are changed, such as estimated reductions of the hazardous waste stream. Sensitivity analysis involves systematically changing one of the assumptions on which the investment analysis is based.

In the example illustrated below, in the most optimistic scenario (*High* scenario) the waste acid stream is eliminated entirely (100 percent). The following table summarizes the P2/FINANCE results from an ECAM application using scenarios where a 75 percent reduction occurs in the waste stream (most likely, or *Medium*, Scenario), and a 50 percent reduction (most pessimistic, or *Low*, scenario). The corresponding impacts on financial indicators are provided in the table.

Sensitivity Analysis: Change in Waste Stream Reduction

Indicator	Hazardous Waste Volume Reduction		
	High	Medium	Low
NPV	\$137,958	\$93,877	\$59,964
Payback Period	0.8 yrs	1.2 yrs	1.7 yrs
IRR	119 %	85 %	58 %

In each of the three scenarios, the financial indicators still support the decision to implement the proposed project. Comparing the *High* to *Low* scenarios, though, the investment becomes less attractive because of costs associated with the handling and management of an increased volume of hazardous waste.

P2/FINANCE can also calculate financial indicators using scenarios where cash flows generated by process productivity improvements are generated. In the example below, the sensitivity analysis is applied to the inventory carrying cost savings estimated as a consequence of a reduction in process cycle time (according to the example provided in ECAM Handbook Section 3.2). In this example, three scenarios were evaluated using variations in annual savings associated with inventory carrying costs. The table below highlights the wide variance that is realized in financial results with the carrying cost scenarios, indicating that this assumption is critical in evaluating the viability of the investment.

Sensitivity Analysis: Inventory Carrying Costs

Scenario	#1 (High)	Initial	#2 (Low)
Assumed Inventory Carrying Cost Savings	\$1,500,000/yr	\$1,090,763/yr	\$500,000/yr
Indicator:			
NPV	\$14,541,896	\$9,828,430	\$3,024,485
Payback Period	0.16 yrs	0.2 yrs	0.8 yrs
IRR	655 %	444 %	139 %

The examples show that conducting a sensitivity analysis is useful for two important reasons:

- Provides information about the range of possible outcomes for the proposed investment
- Enables managers to determine which assumptions most strongly affect the forecast and which are secondary.

9/1/97

PROJECT TITLE: Facility Example Diffusion Dialysis System

PREPARED BY:

ORGANIZATION:

COMMENTS:

Assumptions:

1. Discount Rate = 3.5%
2. Diffusion Dialysis Study Period = 15 years
3. Acid Waste Stream Reduced by 100%
4. Equipment Purchase Cost = \$15,000
5. Equipment Installation/Implementation Cost = \$0

P2/FINANCE

Pollution Prevention Financial Analysis
and Cost Evaluation System

Version 3.0
Copyright 1996
Tellus Institute
Boston, MA

DEFAULT PARAMETERS

Analysis Name: Facility Example Diffusion Dialysis System

9/1/97

Default-pg1

Global Parameters

P2/FINANCE uses the Inflation Rate, Discount Rate, and Income Tax Rate entered here for calculations on the Tax Deduction Schedule, Incremental Cash Flow Analysis, and Incremental Profitability Analysis sheets.

Inflation reflects the overall rate at which you expect prices to increase. For cases in which this Inflation Rate does not fully capture expected price changes, P2/FINANCE allows you to define an additional Escalation Rate for each Annual Operating Cost category.

Inflation Rate

The Discount Rate accounts for the fact that there is an opportunity cost to using money – if you choose to invest in one project, you lose the opportunity to gain a return on another investment. Many companies use their weighted average cost of capital as a Discount Rate. For more information on Discount Rate and its relationship to inflation, see the on-line help.

Discount Rate

State and local income taxes are deductible from the taxable income used to calculate federal taxes. Enter your Local, State, and Federal Income Tax Rates below, and P2/FINANCE will calculate an Aggregate Income Tax Rate.

Local Income Tax Rate
 State Income Tax Rate
 Federal Income Tax Rate

Aggregate Income Tax Rate

The Default Parameters entered by the user in this section can be applied to the entire project file by pressing the button below. **Do not press this button unless you are sure that you want these values to apply to the entire project file!**

P2/FINANCE uses the Depreciation Method and Period entered here as defaults for all Initial Investment Costs. You can change the Depreciation Method and Period for individual categories on the Initial Investment Costs sheet.

Depreciation Method
 Depreciation Period

To specify Depreciation Method, use these abbreviations:

Straight Line	SL
150% Declining Balance switching to Straight Line	1.5DB
200% Declining Balance switching to Straight Line	DDB or 2DB
Expensed (tax deductible in the first year)	EXP
Working Capital (not tax deductible)	WC

The Default Parameters entered by the user in this section can be applied to the entire project file by pressing the button below. **Do not press this button unless you are sure that you want these values to apply to the entire project file!**

Scenario Parameters

P2/FINANCE allows you to create two alternative financial analysis scenarios, which represent different investment options you are considering. You can also create a baseline scenario, which contains data on your current "business-as-usual" operations. On the Incremental Cash Flow Analysis and the Incremental Profitability Analysis sheets, the Alternative Scenarios are compared to the Base Scenario, i.e., P2/FINANCE calculates incremental cash flows and profitability.

The Investment Year and Lifetime entered here are used as defaults for both Initial Investment Costs and Annual Operating Costs. P2/FINANCE assumes that investments occur AT THE END OF THE INVESTMENT YEAR, so the default Start Year for Annual Operating Costs is Investment Year + 1. The most common Investment Year will be Year 0, i.e., most Initial Investment Costs are incurred at the very beginning of the project lifetime.

Alternative Scenario 1

Name

Inv. Year Lifetime

Start Year End Year

Alternative Scenario 2

Name

Inv. Year Lifetime

Start Year End Year

Base Scenario

Name

Inv. Year Lifetime

Start Year End Year

INITIAL INVESTMENT COSTS - Alternative Scenario 1

Alternative Scenario 1: Recycle Acid Bath using Diffusion Dialysis Sys9/1/97

Inv-Alt1-pg1

Initial Investment Costs	\$ Amount
--------------------------	-----------

Purchased Equipment (Purchase, Tax, Delivery)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Process Equipment (DD System, Installed)		\$15,000	
Storage and Materials Handling Equipment			
Safety/Protective Equipment			
Monitoring/Control Equipment			
Laboratory/Analytical Equipment			
Spare Parts			
Salvage Value		TOTAL	\$15,000

Planning/Engineering (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house Planning			
In-house Engineering/Design			
Procurement			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Construction/Installation (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Equipment Rental			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Permitting

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Permit Fees			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Working Capital

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Utility Connections/Systems

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Electricity			
Steam			
Water			
Fuel			
Plant Air			
Inert Gas			
Refrigeration			
Sewerage			
General Plumbing			
Salvage Value		TOTAL	\$0

Site Preparation (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Demolition & Clearing			
Old Equipment/Rubbish Disposal			
Grading/Landscaping			
Equipment Rental			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Start-up/Training (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Trials/Manufacturing Variances			
Process/Equipment Training			
Safety/Environmental Training			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Buildings & Land

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Contingency

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

INITIAL INVESTMENT COSTS - Base Scenario

Base Scenario: Dispose of Acid Bath as a Hazardous Waste

9/1/97

Inv-Base-pg1

Initial Investment Costs \$ Amount

Initial Investment Costs \$ Amount

Purchased Equipment (Purchase, Tax, Delivery)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Process Equipment			
Storage and Materials Handling Equipment			
Safety/Protective Equipment			
Monitoring/Control Equipment			
Laboratory/Analytical Equipment			
Spare Parts			
Salvage Value		TOTAL	\$0

Planning/Engineering (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house Planning			
In-house Engineering/Design			
Procurement			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Construction/Installation (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Equipment Rental			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Permitting

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Permit Fees			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Working Capital

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Utility Connections/Systems

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Electricity			
Steam			
Water			
Fuel			
Plant Air			
Inert Gas			
Refrigeration			
Sewerage			
General Plumbing			
Salvage Value		TOTAL	\$0

Site Preparation (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Demolition & Clearing			
Old Equipment/Rubbish Disposal			
Grading/Landscaping			
Equipment Rental			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Start-up/Training (Labor, Materials)

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
In-house			
Trials/Manufacturing Variances			
Process/Equipment Training			
Safety/Environmental Training			
Vendor/Contractor Fees			
Salvage Value		TOTAL	\$0

Buildings & Land

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Contingency

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

ANNUAL OPERATING COSTS - Alternative Scenario 1

Alternative Scenario 1: Recycle Acid Bath using Diffusion Dialysis Syst9/1/97

Op-Alt1-pg1

Annual Operating Costs	\$ Amount	Annual Operating Costs	\$ Amount
------------------------	-----------	------------------------	-----------

Direct Materials (Purchase, Delivery, Storage)

Escalation Rate	0.0%	Start Year	1
		End Year	15
Raw Materials: HCl (M&E Item)			\$3,074
Solvents			
Catalysts			
Other (Deionized Water - M&E Item)			\$27
TOTAL			\$3,101

Direct Labor (Wage/Salary, Benefits)

Escalation Rate	0.0%	Start Year	1
		End Year	15
Operating: Acid Dip Function (M&E Item)			\$120,000
Supervision			
Manufacturing Clerical			
Maintenance			
Other: HW Drums (M&E Item)			\$0
TOTAL			\$120,000

Regulatory Compliance (Labor, Materials) #1

Escalation Rate	0.0%	Start Year	1
		End Year	15
Permitting (Item 13)			\$0
Training/Instructing (Items 3&4)			\$1,694
Monitoring/Inspections/Audits (Item 1)			\$0
Testing/Sampling Waste Streams (Items 7&8)			\$0
Generator Fees/Taxes			
TOTAL			\$1,694

Product Quality (Labor, Materials)

Escalation Rate	0.0%	Start Year	1
		End Year	15
QA/QC			
Product Rejects			
Product Returns			
TOTAL			\$0

Revenues - By-product

Escalation Rate	0.0%	Start Year	1
		End Year	15
Marketable By-products			
Marketable Pollution Permits			
TOTAL			\$0

Utilities

Escalation Rate	0.0%	Start Year	1
		End Year	15
Electricity for DD system (M&E Item)			\$65
Steam			
Water			
Fuel			
Plant Air			
Inert Gas			
Refrigeration			
Lighting, Heating, Air Conditioning (M&E Item)			\$500
Other: Industrial Wastewater Treatment (M&E Item)			\$13,672
TOTAL			\$14,237

Waste Management (Labor, Materials)

Escalation Rate	0.0%	Start Year	1
		End Year	15
On-site Handling & Storage (direct labor) (M&E Item)			\$0
On-site Pre-treatment			
On-site Treatment			
Hauling/Transport On-Site (indirect labor) (Item 12)			\$0
Off-site Treatment			
Off-site Disposal (Item 9)			\$0
TOTAL			\$0

Regulatory Compliance (Labor, Materials) #2

Escalation Rate	0.0%	Start Year	1
		End Year	15
Labeling			
Manifesting			
Recordkeeping: MSDS/Emer Resp Plan Maint (Item 2)			\$0
Reporting (Item 6)			\$0
Other: HW Mgmt/P2 Plain Maint (Item 5)			\$0
TOTAL			\$0

Revenues - Product

Escalation Rate	0.0%	Start Year	1
		End Year	15
Change in Product Throughput			
Change in Market Share			
TOTAL			\$0

Insurance

Escalation Rate	0.0%	Start Year	1
		End Year	15
Workers' Health Insurance			
Workers' Compensation			
Pollution Liability Insurance			
TOTAL			\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

Other

Dep. Method	wc	Investment Year	0
Dep. Period	0.0	Lifetime	15
Salvage Value		TOTAL	\$0

ANNUAL OPERATING COSTS - Base Scenario

Base Scenario: Dispose of Acid Bath as a Hazardous Waste

9/1/97

Op-Base-pq1

Annual Operating Costs	\$ Amount	Annual Operating Costs	\$ Amount
------------------------	-----------	------------------------	-----------

Direct Materials (Purchase, Delivery, Storage)

Escalation Rate	0.0%	Start Year	1
		End Year	15
Raw Materials: HCl (M&E Item)			\$3,450
Solvents			
Catalysts			
Other (Deionized Water)			
TOTAL			\$3,450

Direct Labor (Wage/Salary, Benefits)

Escalation Rate	0.0%	Start Year	1
		End Year	15
Operating: Acid Dip Function (M&E Item)			\$120,000
Supervision			
Manufacturing Clerical			
Maintenance			
Other: HW Drums (M&E Item)			\$780
TOTAL			\$120,780

Regulatory Compliance (Labor, Materials) #1

Escalation Rate	0.0%	Start Year	1
		End Year	15
Permitting (Item 13)			\$0
Training/Instructing (Items 3&4)			\$1,694
Monitoring/Inspections/Audits (Item 1)			\$30
Testing/Sampling Waste Streams (Items 7&8)			\$780
Generator Fees/Taxes			
TOTAL			\$2,504

Product Quality (Labor, Materials)

Escalation Rate	0.0%	Start Year	1
		End Year	15
QA/QC			
Product Rejects			
Product Returns			
		TOTAL	\$0

Revenues - By-product

Escalation Rate	0.0%	Start Year	1
		End Year	15
Marketable By-products			
Marketable Pollution Permits			
		TOTAL	\$0

Utilities

Escalation Rate	0.0%	Start Year	1
		End Year	15
Electricity			
Steam			
Water			
Fuel			
Plant Air			
Inert Gas			
Refrigeration			
Lighting, Heating, Air Conditioning (M&E Item)			\$500
Other: Industrial Wastewater Treatment (M&E Item)			\$13,646
		TOTAL	\$14,146

Waste Management (Labor, Materials)

Escalation Rate	0.0%	Start Year	1
		End Year	15
On-site Handling & Storage (M&E)			\$12,000
On-site Pre-treatment			
On-site Treatment			
Hauling/Transport On-Site (Item 12)			\$720
Off-site Treatment			
Off-site Disposal (Item 9)			\$2,205
		TOTAL	\$14,925

Regulatory Compliance (Labor, Materials) #2

Escalation Rate	0.0%	Start Year	1
		End Year	15
Labeling			
Manifesting			
Recordkeeping: MSDS/Emer Resp Plan Maint (Item 2)			\$30
Reporting (Item 6)			\$30
Other: HW Mgmt/P2 Plain Maint (Item 5)			\$30
		TOTAL	\$90

Revenues - Product

Escalation Rate	0.0%	Start Year	1
		End Year	15
Change in Product Throughput			
Change in Market Share			
TOTAL		\$0	

Insurance

Escalation Rate	0.0%	Start Year	1
		End Year	15
Workers' Health Insurance			
Workers' Compensation			
Pollution Liability Insurance			
	TOTAL		\$0

Future Liability

Escalation Rate	0.0%	Start Year	1
		End Year	15
Fines/Penalties			
Legal Costs			
Personal Injury			
Property/Natural Resource Damage			
Remediation			
TOTAL			\$0

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
TOTAL			\$0

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
Medical Exams - Medical Labor (Item 10)			\$200
Medical Exams - Lost Labor (Item 11)			\$480
TOTAL			\$680

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
TOTAL			\$0

SCENARIO SUMMARY - Alternative Scenario 1

Alternative Scenario 1: Recycle Acid Bath using Diffu 9/1/97

Summ-Alt1-pg1

INITIAL INVESTMENT COSTS

	Cost	Salvage Value	Inv. Year	Lifetime	Depreciation	
					Period	Method
Purchased Equipment (Purchase, Tax, Delivery)	\$15,000	\$0	0	15	0	WC
Utility Connections/Systems	0	0	0	15	0	WC
Planning/Engineering (Labor, Materials)	0	0	0	15	0	WC
Site Preparation (Labor, Materials)	0	0	0	15	0	WC
Construction/Installation (Labor, Materials)	0	0	0	15	0	WC
Start-up/Training (Labor, Materials)	0	0	0	15	0	WC
Permitting	0	0	0	15	0	WC
Buildings & Land	0	0	0	15	0	WC
Working Capital	0	0	0	15	0	WC
Contingency	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC

ANNUAL OPERATING COSTS

	Cost	Start Year	End Year	Escalation
Direct Materials (Purchase, Delivery, Storage)	\$3,101	1	15	0.0%
Utilities	14,237	1	15	0.0%
Direct Labor (Wage/Salary, Benefits)	120,000	1	15	0.0%
Waste Management (Labor, Materials)	0	1	15	0.0%
Regulatory Compliance (Labor, Materials) #1	1,694	1	15	0.0%
Regulatory Compliance (Labor, Materials) #2	0	1	15	0.0%
Product Quality (Labor, Materials)	0	1	15	0.0%
Revenues - Product	0	1	15	0.0%
Revenues - By-product	0	1	15	0.0%
Insurance	0	1	15	0.0%
Future Liability	0	1	15	0.0%
Other	0	1	15	0.0%
Other	680	1	15	0.0%
Other	0	1	15	0.0%
Other	0	1	15	0.0%

GLOBAL PARAMETERS

SCENARIO PARAMETERS

Project Title: Facility Example Diffusion Dialysis System
 Inflation Rate 0.0%
 Discount Rate 3.5%
 Aggregate Income Tax Rate 0.0%
 Default Depreciation Method wc
 Default Depreciation Period 0

Default Investment Year 0
 Default Lifetime 15
 Default Start Year 1
 Default End Year 15

Future Liability

Escalation Rate	0.0%	Start Year	1
		End Year	15
Fines/Penalties			
Legal Costs			
Personal Injury			
Property/Natural Resource Damage			
Remediation			
TOTAL			\$0

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
TOTAL			\$0

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
Medical Exams - Medical Labor (Item 10)			\$220
Medical Exams - Lost Labor (Item 11)			\$528
TOTAL			\$748

Other

Escalation Rate	0.0%	Start Year	1
		End Year	15
TOTAL			\$0

SCENARIO SUMMARY - Base Scenario

Base Scenario: Dispose of Acid Bath as a Hazardous 9/1/97

Summ-Base-pg1

Base Scenario: Dispose of Add-Batch as a Residual						
INITIAL INVESTMENT COSTS	Cost	Salvage	Inv. Year	Lifetime	Depreciation	
		Value			Period	Method
Purchased Equipment (Purchase, Tax, Delivery)	\$0	\$0	0	15	0	WC
Utility Connections/Systems	0	0	0	15	0	WC
Planning/Engineering (Labor, Materials)	0	0	0	15	0	WC
Site Preparation (Labor, Materials)	0	0	0	15	0	WC
Construction/Installation (Labor, Materials)	0	0	0	15	0	WC
Start-up/Training (Labor, Materials)	0	0	0	15	0	WC
Permitting	0	0	0	15	0	WC
Buildings & Land	0	0	0	15	0	WC
Working Capital	0	0	0	15	0	WC
Contingency	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
Other	0	0	0	15	0	WC
ANNUAL OPERATING COSTS	Cost		Start Year	End Year	Escalation	
Direct Materials (Purchase, Delivery, Storage)	\$3,450		1	15	0.0%	
Utilities	14,146		1	15	0.0%	
Direct Labor (Wage/Salary, Benefits)	120,780		1	15	0.0%	
Waste Management (Labor, Materials)	14,925		1	15	0.0%	
Regulatory Compliance (Labor, Materials) #1	2,504		1	15	0.0%	
Regulatory Compliance (Labor, Materials) #2	90		1	15	0.0%	
Product Quality (Labor, Materials)	0		1	15	0.0%	
Revenues - Product	0		1	15	0.0%	
Revenues - By-product	0		1	15	0.0%	
Insurance	0		1	15	0.0%	
Future Liability	0		1	15	0.0%	
Other	748		1	15	0.0%	
Other	0		1	15	0.0%	
Other	0		1	15	0.0%	
GLOBAL PARAMETERS			SCENARIO PARAMETERS			
Project Title: Facility Example Diffusion Dialysis System						
Inflation Rate	0.0%		Default Investment Year		0	
Discount Rate	3.5%		Default Lifetime		15	
Aggregate Income Tax Rate	0.0%		Default Start Year		1	
Default Depreciation Method	wc		Default End Year		15	
Default Depreciation Period	0					

INCREMENTAL CASH FLOW ANALYSIS

Alternative Scenario 1 vs. Base Scenario

Analysis Name: Facility Example Diffusion Dialysis System

9/1/97

Cash Flow-Alt1 v Base-pg 1

Operating Year	0	1	2	3	4	5	6	7
INCREMENTAL INITIAL INVESTMENT COSTS								
Purchased Equipment (Purchase, Tax, Delivery)	15,000	0	0	0	0	0	0	0
Utility Connections/Systems	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials)	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials)	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials)	0	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials)	0	0	0	0	0	0	0	0
Permitting	0	0	0	0	0	0	0	0
Buildings & Land	0	0	0	0	0	0	0	0
Working Capital	0	0	0	0	0	0	0	0
Contingency	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Initial Investment Costs	15,000	0	0	0	0	0	0	0
INCREMENTAL ANNUAL OPERATING (COSTS)/SAVINGS								
Direct Materials (Purchase, Delivery, Storage)		349	349	349	349	349	349	349
Utilities		(91)	(91)	(91)	(91)	(91)	(91)	(91)
Direct Labor (Wage/Salary, Benefits)		780	780	780	780	780	780	780
Waste Management (Labor, Materials)		14,925	14,925	14,925	14,925	14,925	14,925	14,925
Regulatory Compliance (Labor, Materials) #1		810	810	810	810	810	810	810
Regulatory Compliance (Labor, Materials) #2		90	90	90	90	90	90	90
Product Quality (Labor, Materials)		0	0	0	0	0	0	0
Revenues - Product		0	0	0	0	0	0	0
Revenues - By-product		0	0	0	0	0	0	0
Insurance		0	0	0	0	0	0	0
Future Liability		0	0	0	0	0	0	0
Other		68	68	68	68	68	68	68
Other		0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0
Total Annual Operating (Costs)/Savings		16,931	16,931	16,931	16,931	16,931	16,931	16,931
INCREMENTAL TAX CALCULATION								
Annual Operating (Costs)/Savings		16,931	16,931	16,931	16,931	16,931	16,931	16,931
- Depreciation		0	0	0	0	0	0	0
- Expensed Initial Investment Costs		0	0	0	0	0	0	0
+ Taxable Gain (Loss) on Salvaged Equipment		0	0	0	0	0	0	0
Taxable Income		16,931	16,931	16,931	16,931	16,931	16,931	16,931
Income Tax at 0.0%		0	0	0	0	0	0	0
INCREMENTAL CASH FLOW CALCULATION								
Annual Operating (Costs)/Savings		16,931	16,931	16,931	16,931	16,931	16,931	16,931
- Income Tax		0	0	0	0	0	0	0
- Initial Investment Costs	15,000	0	0	0	0	0	0	0
+ Recovery of Working Capital		0	0	0	0	0	0	0
+ Salvage Value		0	0	0	0	0	0	0
After-Tax Cash Flow	(15,000)	16,931	16,931	16,931	16,931	16,931	16,931	16,931
Cumulative Cash Flow	(15,000)	1,931	18,862	35,793	52,724	69,655	86,586	103,517
Discounted Cash Flow	(15,000)	16,358	15,805	15,271	14,754	14,255	13,773	13,308

INCREMENTAL CASH FLOW ANALYSIS

Alternative Scenario 1 vs. Base Scenario

Cash Flow-Alt1 v. Base-pg.2

Analysis Name: Facility Example Diffusion Dialysis System

Operating Year	8	9	10	11	12	13	14	15
INCREMENTAL INITIAL INVESTMENT COSTS								
Purchased Equipment (Purchase, Tax, Delivery)	0	0	0	0	0	0	0	0
Utility Connections/Systems	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials)	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials)	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials)	0	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials)	0	0	0	0	0	0	0	0
Permitting	0	0	0	0	0	0	0	0
Buildings & Land	0	0	0	0	0	0	0	0
Working Capital	0	0	0	0	0	0	0	0
Contingency	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Initial Investment Costs	0	0	0	0	0	0	0	0
INCREMENTAL ANNUAL OPERATING (COSTS)/SAVINGS								
Direct Materials (Purchase, Delivery, Storage)	349	349	349	349	349	349	349	349
Utilities	(91)	(91)	(91)	(91)	(91)	(91)	(91)	(91)
Direct Labor (Wages/Salary, Benefits)	780	780	780	780	780	780	780	780
Waste Management (Labor, Materials)	14,925	14,925	14,925	14,925	14,925	14,925	14,925	14,925
Regulatory Compliance (Labor, Materials) #1	810	810	810	810	810	810	810	810
Regulatory Compliance (Labor, Materials) #2	90	90	90	90	90	90	90	90
Product Quality (Labor, Materials)	0	0	0	0	0	0	0	0
Revenues - Product	0	0	0	0	0	0	0	0
Revenues - By-product	0	0	0	0	0	0	0	0
Insurance	0	0	0	0	0	0	0	0
Future Liability	0	0	0	0	0	0	0	0
Other	68	68	68	68	68	68	68	68
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Annual Operating (Costs)/Savings	16,931	16,931	16,931	16,931	16,931	16,931	16,931	16,931
INCREMENTAL TAX CALCULATION								
Annual Operating (Costs)/Savings	16,931	16,931	16,931	16,931	16,931	16,931	16,931	16,931
- Depreciation	0	0	0	0	0	0	0	0
- Expensed Initial Investment Costs	0	0	0	0	0	0	0	0
+ Taxable Gain (Loss) on Salvaged Equipment	0	0	0	0	0	0	0	0
Taxable Income	16,931	16,931	16,931	16,931	16,931	16,931	16,931	16,931
Income Tax at 8.8%	0	0	0	0	0	0	0	0
INCREMENTAL CASH FLOW CALCULATION								
Annual Operating (Costs)/Savings	16,931	16,931	16,931	16,931	16,931	16,931	16,931	16,931
- Income Tax	0	0	0	0	0	0	0	0
- Initial Investment Costs	0	0	0	0	0	0	0	0
+ Recovery of Working Capital	0	0	0	0	0	0	0	15,000
+ Salvage Value	0	0	0	0	0	0	0	0
After-Tax Cash Flow	16,931	16,931	16,931	16,931	16,931	16,931	16,931	31,931
Cumulative Cash Flow	120,448	137,379	154,310	171,241	188,172	205,103	222,034	253,965
Discounted Cash Flow	12,858	12,423	12,003	11,597	11,205	10,826	10,460	19,059

INCREMENTAL PROFITABILITY ANALYSIS

Analysis Name: Facility Example Diffusion Dialysis 9/11/97

Profit-pg1

P2/FINANCE calculates three indicators of profitability. (See on-line help for more detailed descriptions.)

Net Present Value (NPV), the most reliable indicator, is the value in today's dollars of the discounted future savings of a project. A positive NPV indicates a profitable project. When considering multiple projects, the most profitable project has the highest NPV.

Internal Rate of Return (IRR) is the Discount Rate for which the NPV of a project would equal zero. An IRR greater than the Discount Rate indicates a profitable project. When considering multiple projects, the most profitable project usually, but not always, has the highest IRR. IRR cannot be calculated for some projects with irregular cash flows.

Discounted Payback is the time period within which the discounted future savings of a project repay the Initial Investment Costs. A shorter payback period often, but not always, indicates a more profitable project because Discounted Payback does not account for cash flows that occur after the payback period. Discounted Payback cannot be calculated for some projects.

P2/FINANCE provides four time horizons for calculating Net Present Value and Internal Rate of Return. P2/FINANCE automatically calculates the profitability over 5, 10, and 15 years. You may choose an optional fourth time horizon between 1 and 15 years.

Optional Time Horizon 3

This analysis calculates the incremental profitability of each Alternative Scenario relative to the Base Scenario.
Base Scenario: Dispose of Acid Bath as a Hazardous Waste

Net Present Value (\$)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 3
Alternative Scenario 1	Recycle Acid Bath using Diffusi	61,444	125,808	188,955	32,435
Alternative Scenario 2	NA	#N/A	#N/A	#N/A	#N/A

Internal Rate of Return (%)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 3
Alternative Scenario 1	Recycle Acid Bath using Diffusi	110.1%	112.8%	112.9%	98.4%
Alternative Scenario 2	NA	#N/A	#N/A	#N/A	#N/A

Discounted Payback (years)

Scenario	Name	Payback
Alternative Scenario 1	Recycle Acid Bath using Diffusi	0.92
Alternative Scenario 2	NA	#N/A

APPENDIX D. MONTE CARLO SIMULATION

Monte Carlo Simulation

The P2FINANCE spreadsheets and the use of the ECAM has two major limitations:

- Spreadsheet work cells can only be changed one at a time. The ECAM utilizes both engineering estimates and ABC techniques to generate multiple cost estimates for a wide variety of activities, the resources these activities consumed and their associated cost drivers. P2FINANCE has over 100 data cost points used in calculating NPV, IRR and Payback periods, while the ECAM recommends several dozen Environmental Cost categories. To analyze the entire range of possible outcomes is difficult using the P2FINANCE spreadsheets.
- The ECAM recommends the use of Sensitivity Analysis or "What-if" scenarios, which results in a single-point estimates or results. The results are expressed in a Net Present Value, Payback Period and Internal Rate of Return estimates for each scenario. The ECAM, when combined with the P2FINANCE spreadsheet, results in a single estimate of what is possible under a specific set of assumptions. The analyst is not however given sufficient information as to the risk or probability of the outcome forecasted.

Using a process called Monte Carlo Simulation, an entire range of possible outcomes and the probability or likelihood of each can be calculated. Most ECAM problems involve elements of uncertainty which are too complex to be evaluated with only one or two scenarios. There are too many input values to calculate every possible result. Monte Carlo Simulation simplifies the "what-if" process through the generation of scenarios by random number tables or through a random number generator on a computer. Monte Carlo Simulation can present a statistical profile of the complete range of possibilities in a complex set of assumptions.

A number of software programs have been developed to simplify the Monte Carlo Simulation process. One simulation program was developed by Decisioneering, Inc. called Crystal Ball® that works in conjunction with third party spreadsheet programs like EXCEL™. Crystal Ball is actually an "add-in" that works directly with your current spreadsheet program.

The P2FINANCE Spreadsheets and Crystal Ball provide a user friendly and simple method for conducting Monte Carlo Simulation on environmental technology projects. The following pages present some of the summary reports and graphics for the ECAM example included in Appendix A. A free trial version of this software is available at <http://www.decisioneering.com>.

Probability of Forecasts

The Incremental Profitability Analysis for Diffusion Dialysis contained in Appendix C denotes a single point estimate of \$61.4k for the NPV at the end of five years. The Sensitivity Analysis for the estimated change in waste stream reduction provides three additional NPV point estimates of \$60.0k, \$93.9k and \$137.0k. In both examples the analyst can not determine the relative risk associated with any of the estimates. As shown in Figure 1, the range and probability of the "what-if" scenario covers a wide range of probable outcomes.

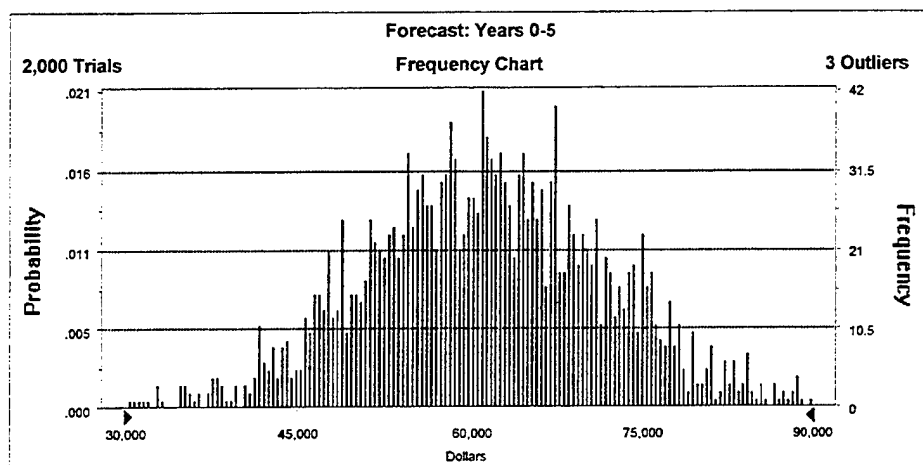


Figure 1

Forecast: Years 0- 5

Summary:

Display Range is from 30,000 to 90,000
 Entire Range is from 30,502 to 93,818
 After 2,000 Trials, the Std. Error of the Mean is

Statistics:	Value
Trials	2000
Mean	61,389
Median	61,286
Mode	—
Standard Deviation	10,324
Variance	106,588,143
Skewness	0.02
Kurtosis	2.90
Coeff. of	0.17
Range	30,502
Range	93,818
Range Width	63,317
Mean Std. Error	230.86

The forecast above reflects the sensitivity analysis of multiple cost factors for 2000 scenarios. The analyst can now associate the risk or probability with the estimated NPV.

The Standard Deviation and Estimated Mean provide the relevant Statistics needed to now associate probability statements with the estimated NPV. Using the +/- 3 Standard Deviations from the Mean the analyst can now determine the probability that the NPV for the Diffusion Dialysis is within the range of \$30.5k and \$93.8k is greater than 95%. The investment decision can now be based on the relative risk.

It should be noted that quantitative uncertainty analysis does not have the designation "worst-case scenario" or "most-probable scenario" as selected distributions encompass all potential scenarios of a given range. That is, distributions are based on the range from no exposure to *worst-case*, with *most-probable* values at some point between. These ranges are described as PDFs. Monte Carlo analysis randomly selects from these PDFs based on identified distributions. The results of this analysis therefore are presented in a range with an identified percent certainty for certain values or ranges of values.

Variable(s) Sensitivities

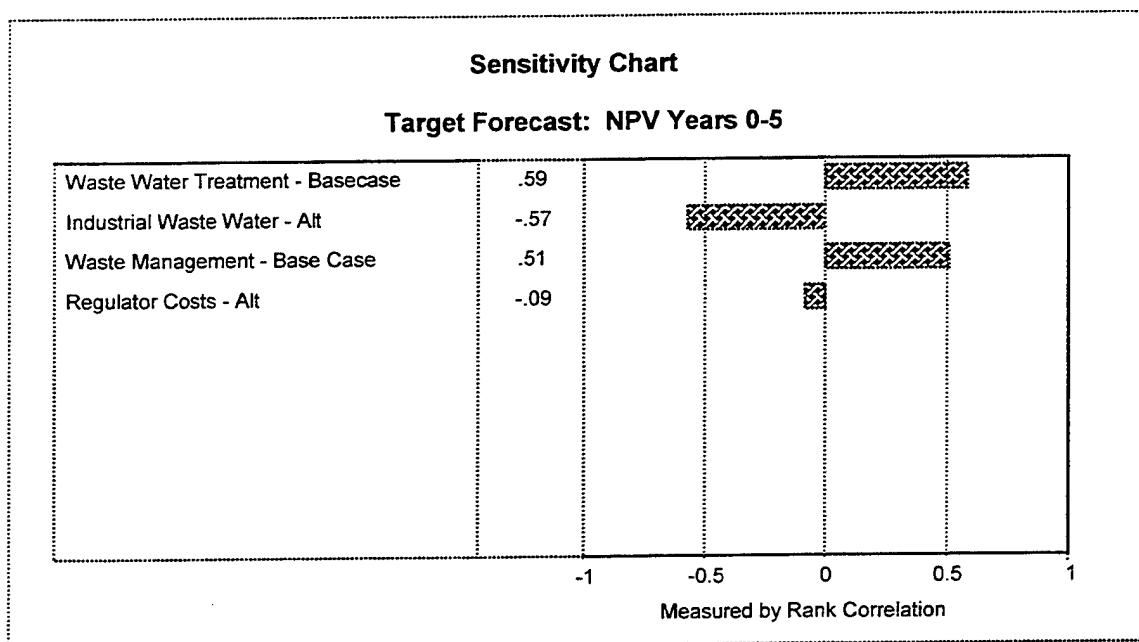


Figure 2

The Sensitivity Chart [Figure 2] allows the analyst to view each variable for its impact or correlation on the forecasted NPV. As shown here the Industrial Wastewater Treatment costs for the Basecase and Alternative Scenario nearly equally offset one another. Therefore the analyst can conclude that these costs are inversely related and do not impact the final result.

The Waste Management cost assumption, in contrast, is positively correlated; accounting for more than half the variation in the model's estimated NPV. Regulator costs are negatively correlated but to a smaller degree. The ECAM recommends an

incremental cost approach; limiting data collection and analysis to only those variables that change. Using the Sensitivity Chart the relative correlation of the variables can be quickly evaluated to eliminate cost factors that minimally impact the results and highlight those cost factors that have the greatest impact on the evaluation.

Shown below are actual screen images of the two software programs: Crystal Ball and P2FINANCE [Figure 3]. Each trial run or scenario is plotted for each forecasted time period in P2FINANCE. As shown there are now a range of probable outcomes based on 2000 different trial runs wherein key variables are randomly changed to simulate multiple cost estimates. Now rather than the single point estimate of \$61,000 for the NPV for the five-year forecast, the analyst can now state that the range of probable outcomes for the estimate is between \$30,000 and \$90,000 with a mean of \$61,000 with a 95% confidence factor.

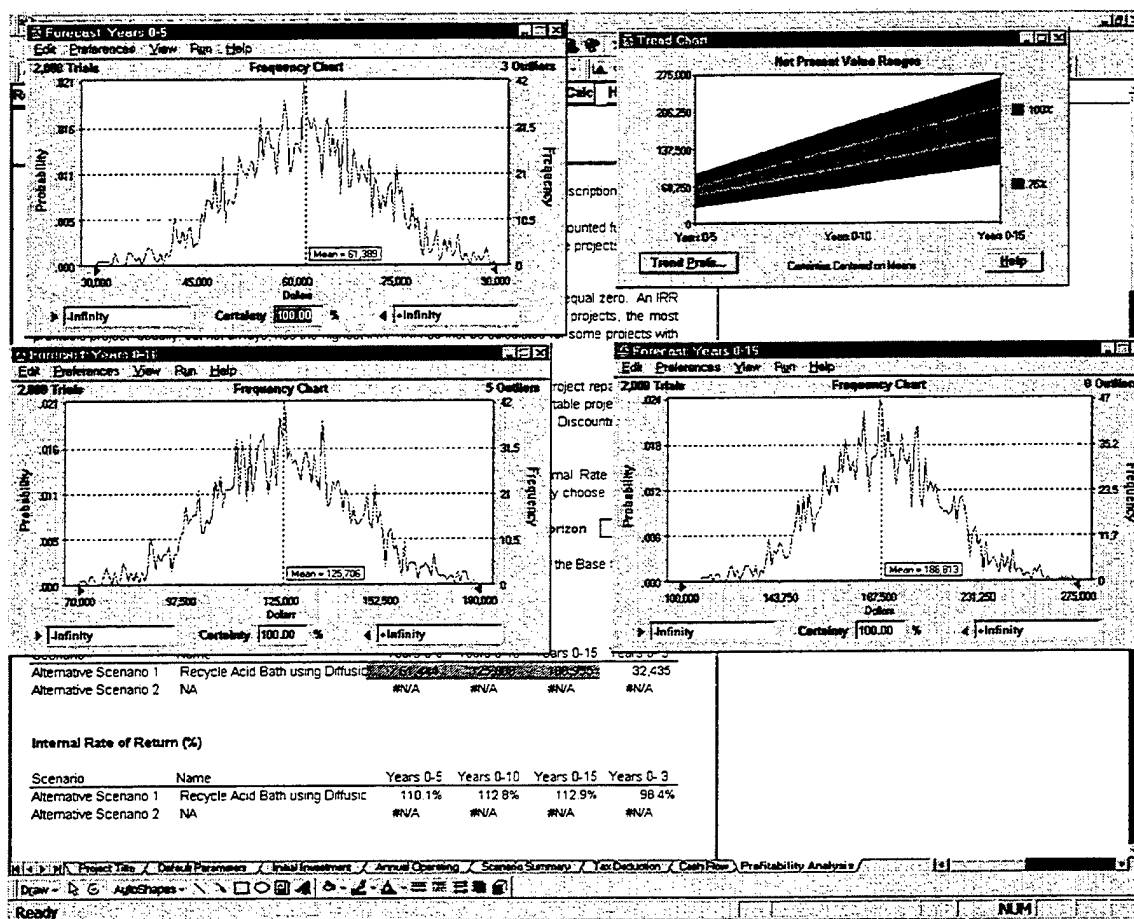


Figure 3

Impact on Data Collection

Monte Carlo Simulation can also be used to compensate for data gaps when collecting and evaluating cost information. Cost information is not always readily available, up-to-date or accurately assigned to the specific process under study. Engineering estimates using range estimates for costs and consumption values are often easier to attain with higher confidence than single point estimates.

APPENDIX E GUIDELINES

GUIDELINES

- Guideline:** The relative value of performing an ECAM analysis is dependent on the number of options available, the ability to influence the decision regarding a specific investment, and the financial benefits of the technology change.
- Rationale:** Must-fund compliance projects or single option alternatives will not benefit from an ECAM study to the same degree as those investments with multiple options and discretionary funding options.
- Guideline:** Small capital investments in new technologies may not warrant the added expense of the Level II environmental cost analysis.
- Rationale:** Additional costs associated with the resources required to identify, collect, compile, analyze, and report Level II costs may not be justified for small capital investments. On the other hand, Level I costs and Level III costs are typically tracked and/or can be easily estimated.
- Guideline:** Spend more time on larger cost drivers.
- Rationale:** The largest cost elements will have the largest impact on the economic metric.
- Guideline:** Do not chase the low value cost factors (i.e., costs that are less than 5% of total process costs).
- Rationale:** Each additional environmental activity adds progressively less value to the analysis.
- Guideline:** Use the "incremental" approach—only estimate costs that will differ from one alternative to the next.
- Rationale:** Costs that do not differ among alternatives will not have an impact on the bottom line.
- Guideline:** Do not add organizational overhead or multipliers to direct costs.
- Rationale:** ECAM allocates overhead costs to a process; therefore, adding overhead double counts these costs.
- Guideline:** Indirect or overhead environmental costs (Level II) are not likely to exceed 50% of direct operating costs (Level I).
- Rationale:** Level II environmental costs represent the assignment of overhead costs to a process or technology using specific activity drivers. Limited experience to date has shown that Level II environmental costs, while greater than previously estimated, have not exceeded 50% of current Level I process costs. This is most likely the case when the cost of waste disposal and hazardous material costs are already captured in the Level I analysis.

GUIDELINES

- Guideline:** Any one technology option is not likely to reduce environmental overhead operating budgets more than 10%.
- Rationale:** The assignment of the environmental overhead operating budget is determined by the number of activities and their associated drivers. Numerous process and technologies are supported by the environmental department budget. It is unlikely that any one process would require support services (i.e., resources) exceeding 10% of the department's operating budget.
- Guideline:** Evaluate all projects using the same discount rate.
- Rationale:** Consistent application of economic factors is essential for making valid comparisons among projects. Use the nominal discount rate as published by the Office of Management and Budget in February of each year.
- Guideline:** Use multiple life assumptions—5, 10, or 15 years—for equipment.
- Rationale:** Equipment life estimates for new processes may be highly uncertain.
- Guideline:** Do not consider inflation.
- Rationale:** Adjusting the current operating costs for inflation over the estimated life of the technology and then discounting the future cash flows by the real discount rate (which includes the same inflation component) has no impact on the Net Present Value. Not inflating the future costs and discounting the results using the nominal interest rate will give the same result. An exception to the rule is if a cost element (i.e., material costs) is expected to increase at a rate above the general cost of living increases (e.g., FreonTM). (Note: This recommendation differs from most economic analysis guidance where economic estimates include inflation to account for multiple future capital investments and the need to forecast budget requests in future dollars.)
- Guideline:** Do not consider taxes or depreciation for government facilities
- Rationale:** Government activities are not subject to taxes. Depreciation is an accrual accounting technique to spread the cost of equipment over its useful life. Generally, depreciation methods are used by private sector companies for tax liability purposes and/or internal budgeting. Government organizations report operations on a cash basis.
- Guideline:** Always do Level I (Direct Costs) first and run the analysis.
- Rationale:** If the Level I economic analysis is conclusive, further analysis is unnecessary.
- Guideline:** Consider Level III (Other Costs) when Level I and II are not conclusive.
- Rationale:** Consideration of Level III costs may identify substantial process improvement opportunities.

GUIDELINES

- Guideline:** Do not include a cost estimate for salvage value.
- Rationale:** The costs of disassembly, transportation, retrofitting, and re-installation of unique or specialized technologies are likely to equal or exceed the salvage value of the equipment.
-
- Guideline:** Do not include working capital estimates (e.g., material inventory, first year labor costs, material costs).
- Rationale:** Working capital represents an estimated cash reserve for the anticipated first year operating costs. It is unlikely that a technology or process change will significantly change the cash out flow for the organization requiring a separate cash reserve. Proposed changes should improve operations (lower costs and increase savings) therefore improving the organization's cash flow. Assume that the current cash flows are adequate to support the change.
-
- Guideline:** Do not include a contingency reserve in the estimated cost of capital.
- Rationale:** A contingency estimate represents the cost estimator's confidence in the reliability of the other capital cost estimates and assumptions. The ECAM approach includes a sensitivity analysis of key cost factors. The sensitivity analysis provides a range of possible or "contingent" outcomes.
-
- Guideline:** Use the same production level as the baseline process.
- Rationale:** A new technology may increase the production capacity of the facility, increasing the potential output. However, unless a current backlog or clear indication of increased (or decreased) production or process levels exist, assume the production levels will remain at the current level throughout the period.

APPENDIX F ASSUMPTIONS

DEFAULT ASSUMPTIONS

Discount rate:	2.7% (Effective January 1999) OMB Circular A-94.
Rate of Inflation:	0%
Depreciation:	Do not depreciate capital investment, expense in period incurred
Taxes:	N/A
Average Labor Rate:	\$28 per hour (note that this is a direct rate, not burdened with overhead)
Equipment Life:	Use 5 years, 10 years, and 15 years

The following data table provides default values for the cost of residential, commercial, and industrial utilities. The values were obtained from the Department of Energy's (DOE's) Energy Information Administration and are based on average delivered cost per unit (e.g., cents per kilowatt hour) to U.S. consumers. Additional/updated information can be obtained by visiting the DOE's website at: <http://www.eia.doe.gov/>.

Utility Rates (U.S. Averages)			
	Residential	Commercial	Industrial
Electric (dollars/kilowatt hour - 1998)	\$0.0825	\$0.0974	\$0.0448
Natural Gas (dollars/thousand cubic feet - 1997)	\$6.94	\$5.79	\$3.59
Fuel Oil (no. 2 distillate, dollars/gallon excluding taxes - 1997)	\$0.984	\$0.674	\$0.712
Propane (dollars/gallon excluding taxes - 1997)	\$0.874	\$0.848	\$0.792
Typical Overhead Costs			
Sampling & Analysis	12% of Environmental Compliance Budget		
Studies and Surveys	13% of Environmental Compliance Budget		
Training	4% of Environmental Compliance Budget		
Planning	7% of Environmental Compliance Budget		
Fees & Permits	8% of Environmental Compliance Budget		
Solid Waste Disposal	\$0.25 Per Pound		
Hazardous Waste Disposal	\$1.00 Per Pound		

DEFAULT ASSUMPTIONS

Exhibit 1 is an estimate of percentage allocation of overhead costs by activities for environmental compliance for a typical DOD facility. Cleanup activities represent the single largest cost item for most facilities, estimated at approximately 20% of the overall annual budget. Hazardous waste disposal is the second largest activity representing 18% of total annual expenditures. Sampling and analysis, and studies and surveys represent 12% and 13%, respectively of the estimated annual expenditures. Fees and permitting costs account for 9% of the estimated annual expenditures. Manpower costs for Program Management and administration accounted for 7% of the overall budget.

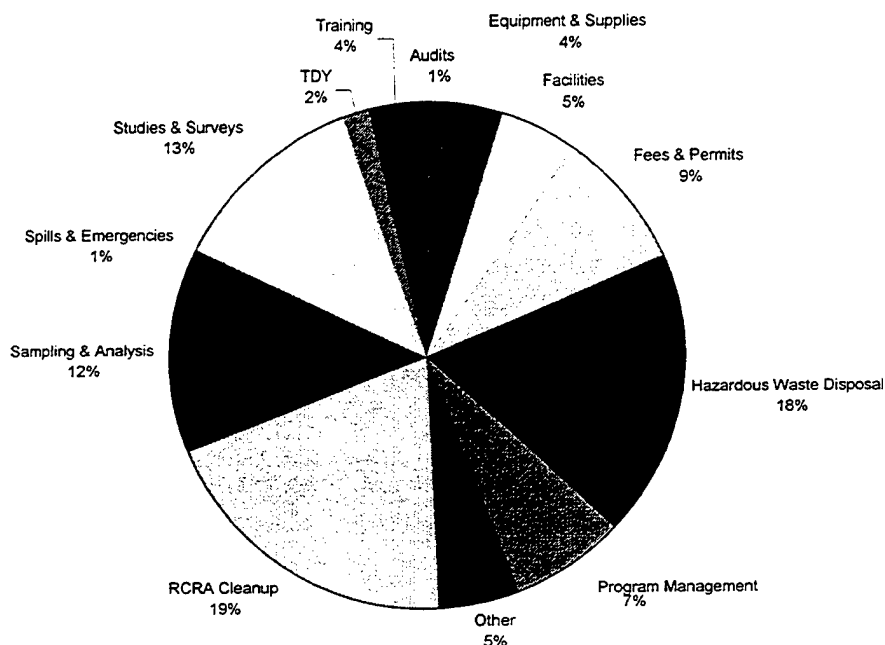


Exhibit 1. Environmental Compliance Costs - Percentage of Total Annual Budget

These percentages are based on NDCEE estimates, which may vary significantly from installation to installation. However, these percentages may provide the ECAM user with a basis for estimating costs where the final installation location is unknown or more precise estimates are not readily available.

DEFAULT ASSUMPTIONS

	Low Estimate	Average Estimate	High Estimate
Audits	1%	2%	5%
Equipment & Supplies	2%	3%	4%
Fees & Permits	3%	7%	9%
Hazardous Waste Disposal	12%	17%	18%
Program Management	7%	13%	30%
Clean-up	19%	22%	22%
Sampling & Analysis	4%	6%	12%
Studies & Surveys	7%	8%	13%
Training	2%	4%	4%
Travel	1%	2%	2%
Other	3%	5%	5%

**Table 2 - Estimated Range of Environmental Compliance Costs
by Activities as Percentage of Annual Budget**

Table 2 provides an estimated range of percentage values for the key environmental compliance costs. These percentages can be used to establish a range estimate for the ECAM user's scenarios. These percentage values can also be used to bound the Monte Carlo simulations by providing an upward and lower boundary and distribution assumptions.